VOLUME VIII #2 DECEMBER 1992 PRICE $6

FOR THE DESIGN, CONSTRUCTION AND ENJOYMENT OF UNUSUAL SOUND SOURCES

EXPERIMENTAL MUSICAL INSTRUMENTS

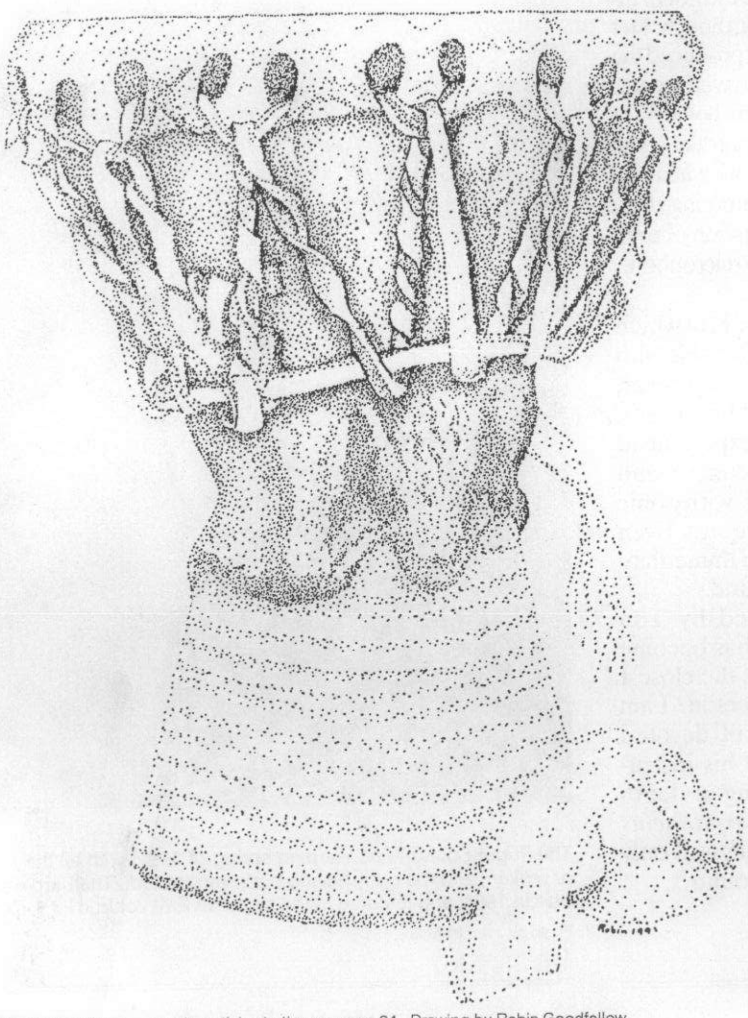
IN THIS ISSUE

... AND MORE

Some of the strangest and most beautiful wind instruments the world has seen can be found among the vessel flutes of Pre-Columbian Mesoamerica. The clay fipple flutes appear in an infinite variety of shapes, with multiple chambers conjoined in the most remarkable configurations. In this issue of **Experimental Musical Instruments** we have an extended article on Pre-Columbian flutes by performer and ceramicist Susan Rawcliffe, who has researched the early American flutes extensively both in the field and in the workshop, making of like specimens to study their acoustic properties.

Also in this issue we have two articles on systems for mapping molecular light absorption and refraction data into musical patterns. We have Glenn Engstrand's report on Motorized Guitar Objects (small electric motors used for their electromagnetic properties to drive guitar pickups) and Robin Goodfellow's notes and drawings on drum lacing methods. Reed Ghazala continues his series on *circuit bending*, being the art of coaxing unintended sounds from cheap electronic audio components. Luc Reid talks about kitchen percussion. And there is the usual additional mix of letters, reviews, and additional odds and ends.

Welcome. Read.



Glazed hourglass drum — see the article starting on page 24. Drawing by Robin Goodfellow.

I WANT TO RESPOND to Mike Hovancsek's review of Akio Suzuki's **Soundsphere**. Rather than discuss his comments on this package, I want to express my own views on Suzuki's work as such and as presented in this CD + booklet. Part of it will be taken by kind permission of **Musicworks** from a review I wrote about it for their issue #50, Summer of 1991.

In his art Akio Suzuki has always concentrated on listening as an active process. In 1960 he started his Self-Discovering Exercises: private and public experiments with the reflection of sound in different environments. They are "acts" of reflection in more than one sense: echo for him is an aural mirror. Listening to sounds he produces is a way of fathoming himself.

His Analapos (strongly reminiscent of a children's "telephone": two tins connected by a long coiled spring) is an extension of this concept, as it creates persistent reverberation. His Glass Harmonica, consisting of five horizontal glass tubes played with various techniques, produces a wide gamut a fragile timbres. This makes the instrument very well suited for exploring the character of a space in response to his action in it. An additional aspect of performance, he told me, is that the audience is yet another mirror, interacting with his exploration through their attention. This shared awareness instigated through the medium of sound, making perception an experience in itself, is the aim and the merit of this master of listening.

With this in mind it is significant that Suzuki's work was never really documented. Is seems hardly possible to capture the gist of his explorations. **Soundsphere** comes surprisingly close to it, though. Het Apollohuis [the Dutch arts presenting organization that produced the package] was willing and able to fully provide the care his work needs. There Suzuki had ample space and time to try out where, how and at what hours he preferred to have his instruments recorded. The recording engineer, Marja Stienstra, was prepared to work whenever Suzuki wanted, which turned out to be very early in the morning when traffic noise was minimal. To guarantee a clear registration of even the faintest sound, she used a Calrec sound-field stereo microphone, which can zoom in on particular spots in space.

In the meantime Suzuki wrote the text of the book, in which he tells about the background of his work, expanding this with hand-drawn scores of several of his sound-events. Moreover, the point of including them only as visual representations lies in the fact that the events should primarily be experienced directly, on the spot. In this form the scores are concise and accurate graphic representations of occurrences with sonic content, neatly catching Suzuki's sense of humor. Even though they look casual, all involved deliberate and immediate interaction of production and consumption of sound.

Through all this meticulous work, matched by Ton Homburg's design of the package, **Soundsphere** has become a true and sincere portrait of Suzuki: I think this is the closest you can come to him, short of witnessing him in person. I am convinced that this issue is quintessential for all devoted readers of EMI, maybe not so much because of his instruments as such, but because Akio Suzuki is dealing in depth with the phenomenon that *Experimental Musical Instruments* is basically about: listening as an experience. That, and only that, is the genuine basis of all investigation into sound.

René van Peer

I NOTICED YOUR AD in Folk Harp Journal and which includes the silhouette of the Puget Sound Wind Harp built by Ron Konzak. My last trip to Seattle was to visit my eldest son and daughter and to visit with my new grandchild. Son Guy is an architect and somewhat builder of banjos, hammered dulcimers. I thought we should go see the Puget Sound Wind Harp because I sent him a tape made when the harp was first built.

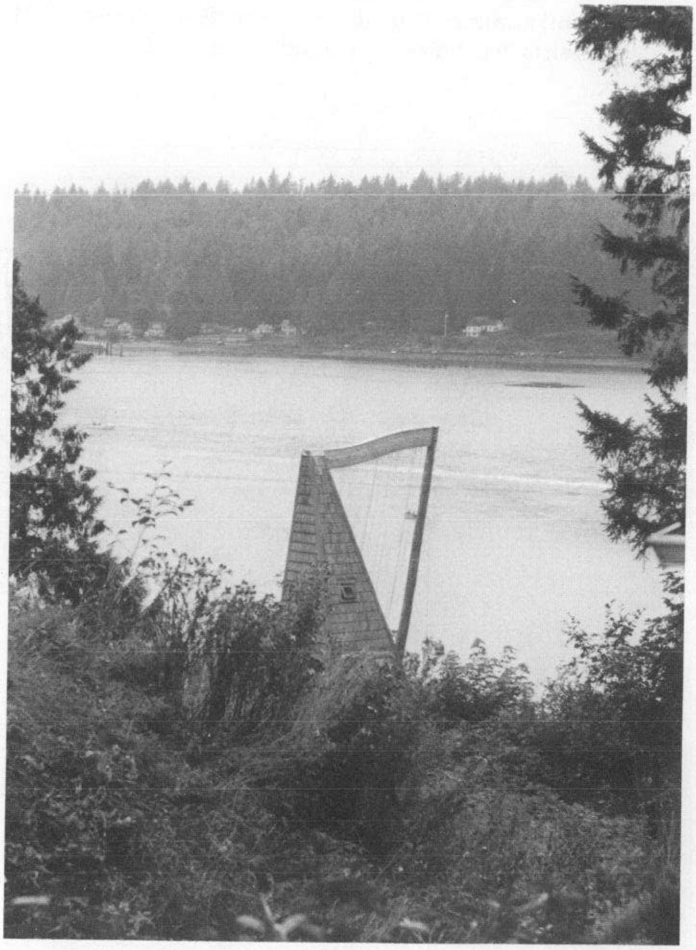
It was difficult to find, but after three false starts we finally found the house where Ron Konzak lived (he has moved from the area) and people showed us the direction to go to get to it.

It is completely abandoned and has been vandalized. The strings are broken or hanging loose so it no longer sings.

We hope to find Ron Konzak, to supply us with information so that on our next trip perhaps we can draw attention for need of repair of a landmark site.

Thought you might be interested.

John J. Maluda



The Puget Sound Wind Harp, in spring of 1992, with all the strings loose or broken, and the body having been vandalized. The harp was originally built in 1984, and featured in the pages of EMI Volume I #5, October 1985

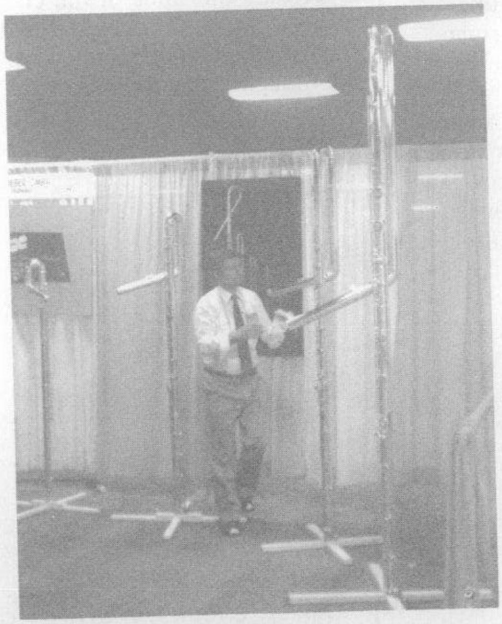
Photo by John Maluda.

AN EARLIER ISSUE of EMI had an article on **Membranes as Reeds** [Vol VII #3, November 1991] and inspired me to create such a "gate" on a bass clarinet body I had been given about 20 minutes before a gig. It was held on with *scotch tape* and I had no idea if it would work (except in theory) - but it did, and I played it through a substantial range of the instrument, w/multiphonics, etc. ... to some effect – and puzzling some audience members. The show was a display of seven instruments prefaced by a misleading, entirely made-up and illogical but straightfaced lecture on acoustics.

John Berndt

RECENTLY, I ATTENDED the National Flute Association convention in Los Angeles. At the exhibitor's hall, they displayed several flutes which I had not seen before. You may find them interesting. At the Max Hieber booth, they had flutes which are an octave and two octaves below normal alto and bass flutes. Pictures of these monsters are enclosed [see below]. The largest flute rises vertically about ten feet above the floor, returning down to mouth level where it turns horizontal. The diameter was about 2.5 inches. At the Kotato and Fukushima booth, a contrabass flute was displayed which was used in concerts at the show. It was surprisingly loud, more so than bass flutes I've heard.

Wesley Brown



Above left: Kotato and Fukushima contrabass flute in C, played by Toby Caplan.

Above right: Max Heiber bass flute in G, contrabass flute in C, subcontrabass flute in G, and subcontrabass flute in C.

The following letter is addressed to reviewer Mike Hovancsek.

Mike,

Thanks for the kind comparisons to Oregon and Paul Winter in your review of the Petite Mal **World Seizure** cassette in E.M.I.

However, you must have run out of steam when you heard our tape, as, unlike all the other reviews, you didn't mention the musicians. How can this be I thought? Perhaps this might be due to the fact that half of our cassette was "lightweight fluff" and that you would be able to diminish the new age aspect of the music by not giving credit (or debit)? So, I went back through the rest of reviews and came to realize that you do have a bias against new age music, which is too bad insofar as many designers of *new* types of instruments also play *new* music, and you are after all reviewing music for a magazine about experimental *new* instruments. New age music is happening not only in the U.S. but around the world so I think you need to catch up a little. Please be fair about your criticism. A music bias is not fair – especially in E.M.I. New Age music or New Music is a music of the present day – expressed by sonic artists and musicians which make it as viable and alive as any art form.

Richard Waters, on behalf of all the players in Petite Mal on the **World Seizure** *cassette — Gary and Mike Knowlton, Eric Pinkham, Geoffry Baugher, Darrell DeVore, Rudy Giscombe, Cliff Zyskowski*

Mike Hovancsek responds:

Richard

I think our disagreement is one of semantics. My criticism is not for that which is "new," but rather for that which falls under the heading of "new age." New age music is made up of things that are new in much the same way that Moon Pies are made up of things that come from the moon.

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SUBMISSIONS: Experimental Musical Instruments welcomes submissions of articles relating to new or unusual musical instruments. A query letter or phone call is suggested before sending articles.

New age music, as I'm using it here, tends to be more concerned with being relaxing and unengaging than with being unique, challenging, or truly "new." I feel that it is important for EMI readers to be informed when a recording of this type predictably fails to explore the interesting qualities of the instruments used. Thus, if a person is biased for being critical of music that refuses to explore new ideas or that limits itself to the vapid parameters of elevator music, I am *very* biased.

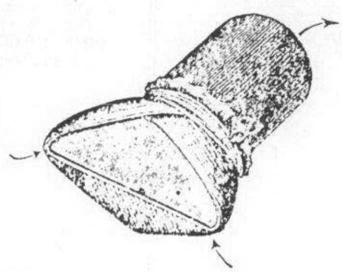
Mike Hovancsek

From the editor: Clearly, as Mike Hovancsek suggests, the phrase "new age" means different things to different people. While our reviewer has criticized certain musical qualities that he feels have come to be associated with the phrase, EMI as a whole doesn't seek to promote any particular musical style over any other, and remains committed to support for creativity in the construction and use of musical sound sources wherever we find it.

EMI's recordings reviews section has in recent months grown considerably, under Mike Hovancsek's pen. While our feature articles maintain their well-defined focus on particular sound instruments, the reviews help provide a larger perspective by opening a window to a wider range of approaches to sound manipulation. With this in mind, we have made arrangements to bring more reviewers into the fold starting with the coming issue. Their varied backgrounds will be essential in contributing to that larger perspective.

NOTES FROM HERE AND THERE

IN EMI'S NOVEMBER 1991 ISSUE (Vol VII #3), we had an article on membrane reeds, which included a brief discussion of what the article called "labial reeds". (The term "reeds", in this context, refers to any air-gating system that breaks the air-flow entering a wind instrument tube into a series of rapid pulses – e.g., the beating reed on a clarinet, the player's lips on a trumpet, or the membrane reeds described in the article.) The "labial reeds" referred to in the article are an eccentric type, rarely if ever used in musical instruments, the most familiar example being the stretched mouth of a balloon, squealing as air rushes out. But Peter Whitehead has sent a note pointing out that Hermann Helmholtz described a similar reed-like mechanism in his 1885 treatise **On the Sensations of Tone**, calling it "Membranous Tongues." On page 97 of the Dover reprint edition (New York: 1954), Helmholtz describes making one of "vulcanized india-rubber". He uses the mechanism primarily as a model for studying the movement of the lips in brass instrument playing, and the larynx in singing -- both of which represent biological versions of the same principle.



Helmholtz' "membranous tongues"

AND IN EMI'S JUNE 1991 ISSUE (Volume VII #1) we had an article on computer control for acoustic instruments, focusing on electro-mechanically played, computer-controlled acoustic pianos. Such instruments have been around since the appearance of the Marantz Pianocorder in the late 70s. In 1988, Yamaha introduced its *Disklavier*, with more aggressive marketing. But even when the EMI article was being written less than two years ago, the idea of a computer-driven acoustic instrument still had a new and exotic ring to it. Now, *Music Trades* magazine reports that Disklavier sales make up 28% of Yamaha's piano sales by dollar volume. What was once an off-beat notion seems to have become a mainstay of the industry.

The Disklavier can record real-time human keyboard performances to computer disk and play them back later; recorded performances can also be edited, or entire pieces composed on disk; and the system is MIDI-compatible. An ever increasing library of pre-recorded pieces for playback is available on disk, and Yamaha has recently introduced a compatible companion synthesizer unit in the form of a 28-note polyphonic tone generator.

THE CONVENTION ON INTERNATIONAL TRADE IN ENDANGERED SPECIES (CITES), in a meeting of delegates from 115 nations in March 1992, has extended its restrictions to include a ban on trade in Brazilian rosewood. The ban includes not only newly cut wood, but any item including any rosewood. Interpreted in its strictest fashion, it could prevent transportation of any such item across national boundaries without special export permits. Included in the ban would be literally millions of privately owned older musical instruments having rosewood components. It remains to be seen how strictly the restriction on existing musical instruments will be interpreted and enforced.

SUBSCRIPTION PAYMENTS FOR OVERSEAS SUBSCRIBERS: EMI unfortunately can't accept payment in foreign currency, or checks labeled as U.S. dollars but drawn on a foreign bank. Our bank costs for cashing such checks are too large -- often larger than the value of the check. If you pay by check or money order, the check must be drawn on or payable through a bank in the United States. Foreign banks can arrange to do this, though they will charge a fee. A less expensive alternative where the risk is not too great is to send cash directly by certified mail.

COMPLEX ACOUSTICS IN PRE-COLUMBIAN FLUTE SYSTEMS

by Susan Rawcliffe

This paper was published in the textbook **Musical Repercussions of 1492: Encounters in Text and Performance** (Smithsonian Institution Press, 1992), and was presented in an earlier version at the Smithsonian Institution during a conference of the same name.

Instrument makers of the Mesoamerican Pre-Columbian societies created a remarkable flute organology, the product of thirty centuries of experimentation and use. Their instruments – flutes, pipes, ocarinas, and whistles – were made in a wide diversity of shapes and sound formats, many of which were unique to these early societies. Although particular cultures specialized in types of instruments, a general continuity of thinking appears across thousands of miles and thousands of years. In fact, Robert Stevenson summarizes the research of several scholars concerning the "aboriginal organography before Cortes," citing that "a notable sameness prevailed in the types instruments used." (1968:18) He also reminds us that Aztec musical instruments are not so much the "remains of a bygone art as the sacred sound symbols of a now-vanished cult" (1968:30).

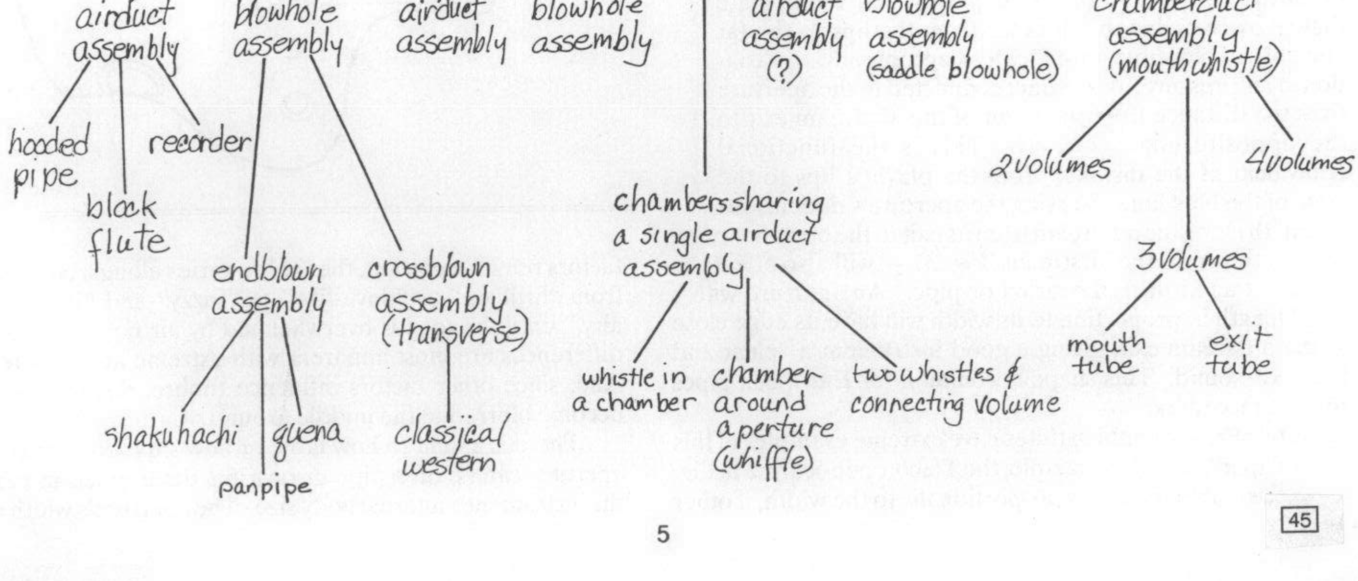
The implications of Pre-Columbian technologies are vast and interconnected. From the architectural dimensions of ball courts to the structural combination of clay flutes, we find a deep scientific and perhaps spiritual concern with acoustics. To this day, traditional Native Americans associate sound with universal forces. For them, sound is a vehicle for communication with the ancestors and deities, who often respond to specific frequencies or tonal and rhythmic configurations (Boiles 1967; Robertson 1992).

Pre-Columbian flute makers developed a highly evolved understanding of how these instruments work. They knew how to manipulate construction techniques in order to produce a particular sound. Often the desired result seems to have been the control of timbre, resulting in an astounding variety of soundscapes.

In part, the range of Mesoamerican flute types derives from their typical medium, clay. In these ancient cultures, ceramics was a major technology with master practitioners. Then, as now, clay was readily available. Because it is so malleable, it can be formed with some precision into almost any desired shape, easily uniting sound and sight. The use of clay as a medium may have promoted vessel flute construction: it is relatively easy to fashion enclosed forms from clay and to combine these forms into one instrument. Although the firing process does change the clay objects, sometimes unpredictably, it can be largely regulated by an expert. Once fired, the clay instrument, if unbroken, will endure as made.

These instruments have fascinated me for many years. As an artist-musician, I have been researching, making, and playing ceramic wind instruments for more than fourteen years. I first began studying ancient flutes to improve my ability to construct them. My research evolved through a circular process of making acoustical copies of ancient specimens, learning to play them, and finally reinvesting my new insights into the creation of new instruments. In other words, for me, Pre-Columbian flutes rep-

FIGURE 1



resent a living tradition, having influenced my perceptions and abilities as a musician and instrument builder. Most of the information in this paper is derived from observations of patterns occurring in both ancient flutes and in my own creations. I will discuss how sound can be, and was, manipulated by sophisticated techniques of instrument construction. Additionally, diverse Pre-Columbian flutes will be "dissected" to illustrate how particular sounds were created through conscious choices made in the production process. The laws of acoustics dictate the range of possibilities for instrument construction, within which cultural and individual preferences can determine particular design decisions. Through descriptions of these factors I hope to reveal the cultural genius exhibited by the makers of these instruments.

Our discussion will focus on specific types of construction techniques. Figure 1 illustrates instrument types and relationships. Definitions of flute nomenclatures are listed in the appendix.

EDGETONE ASSEMBLIES

A limited number of Mesoamerican Pre-Columbian flutes with crossblown assemblies have been found primarily among the Gulf Coast cultures. Endblown flutes such as *kenas* (*quenas*), although customary in many early South American cultures, are rarely found further north (although those made from perishable materials may have disintegrated). The panpipes common to South American cultures were also rare in the Mesoamerican world. In West Mexico (see Franco 1971), they were usually made out of perishable materials. Vessel flutes with blowholes, such as snail-shaped instruments from Narino, Columbia, or hybrid flutes with lip-rest blowhole-assemblies, are more common.

Throughout the Pre-Columbian world, tubular and vessel flutes with airduct assemblies are prevalent. This type of assembly is complex, owing to the interrelationships among its parts: the airduct, aperture, and edge; as well as the interaction of the entire assembly with the body of the instrument. How the assembly is shaped and constructed in large measure determines timbre, range, tone stability, responsiveness, and loudness – in short, the quality of the pipe or ocarina.

APERTURE CONSIDERATIONS

Aperture shape affects an instrument's timbre and loudness. A transverse flute player can manipulate timbre by changing the distance from the lips to the far edge of the blowhole, often with an accompanying variation in air pressure. An airduct connected to the aperture fixes the distance from the point of the airstream exit to the opposite edge (Fig. 2). This is the functional equivalent of the distance from the player's lips to the edge of the blowhole. Varying the aperture's dimensions – length along the airstream from its exit to the opposite edge, and width across the airstream (Fig. 3) – will also affect the timbre of an airducted ocarina or pipe.[2] An aperture with a small length in proportion to its width will have its edge close to the airstream exit, giving a good instrument a "clear and focused" sound. This shape is common for European pipes such as recorders.

A few Pre-Columbian flutes have extreme examples of this type of aperture – for example, the Tlacotepec ocarina in Fig. 4. As the length increases proportionally to the width, if other

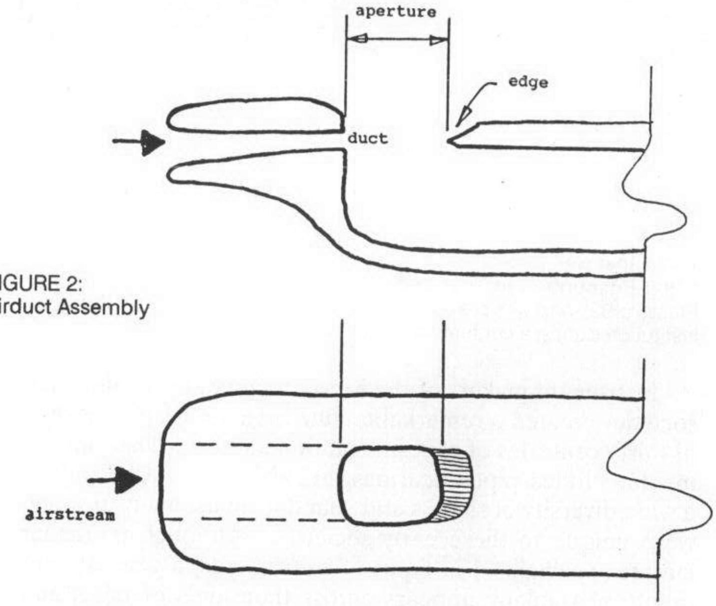


FIGURE 2:
Airduct Assembly

FIGURE 3: Some aperture shapes

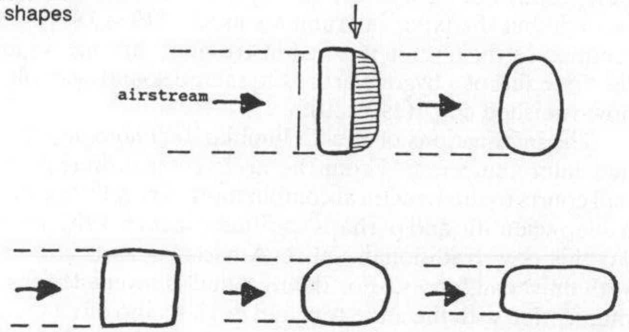
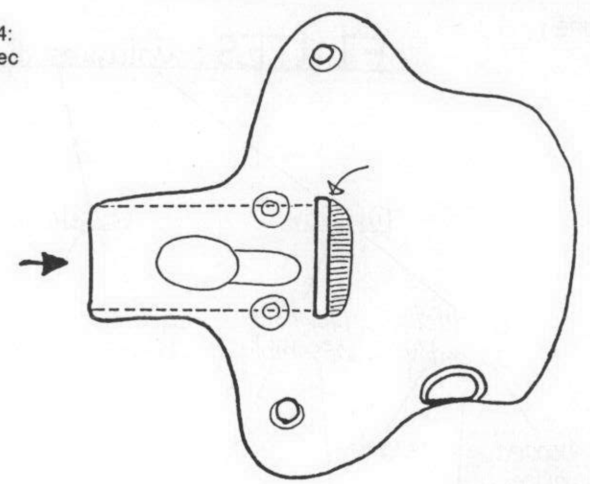


FIGURE 4:
Tlacotepec ocarina



factors remain constant, the timbre varies along a continuum, from "brilliant" to "dove-like" to "fuzzy" and "increasingly airy," until the tone is overwhelmed by air noise. Naturally, differences are most apparent with extreme aperture forms. And, since other factors influence timbre, distinctions may become blurred in the middle ground.

There is a limit to how large or how small the area of the aperture can be on a pipe or ocarina, determined in part by the instrument's internal body size. The aperture's width must

therefore vary somewhat with the length. In general, instruments with a large aperture play more loudly than those with smaller ones.

Figure 5 gives the spectrum analysis of two ocarinas with similar internal volumes and partials. The proportion of the aperture of ocarina A is 1 L (length) to 4 W (width); that is, the width across the airstream is four times the length along the airstream. The aperture proportions of the ocarina B are 21/2 L to 1 W. The hatching across the bottom of the latter's spectrum clearly shows greater air noise present. The timbres of the two instruments reflects their spectrum differences: that of ocarina A is more brilliant; that of B is more open.

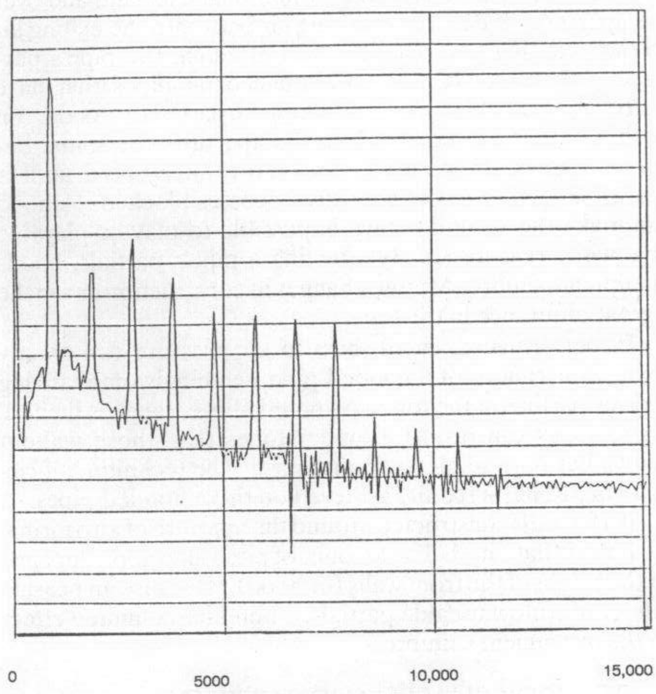
There is a wide diversity of aperture shapes among Pre-Columbian pipes and ocarinas from various cultures. The customary shape varies from square to oval, to an elongated rectangle with the edge relatively far from the exiting airstream (Dorantes and Garcia 1981).

As the aperture's length increases, more air pressure is necessary to get a clear tone with a minimum of air noise. Both loudness and pitch vary directly with the air pressure. The amount of pitch variation depends on the flute type and the construction of the edgetone assembly. For ocarinas with the edge close to the exiting airstream, the tone may disappear with a nominal increase of air pressure. When the edge is farther from the exiting airstream, more air pressure can be applied without causing the tone to disappear. As the aperture lengthens, the pitch can rise further before being eliminated by air pressure increases. With the edge close to the exiting airstream, a pipe will overblow more readily to the second octave with modest increases of air pressure than a pipe with an aperture of greater length. This factor thus affects not only the instrument's timbre but also the performer's ability to bend a pitch.

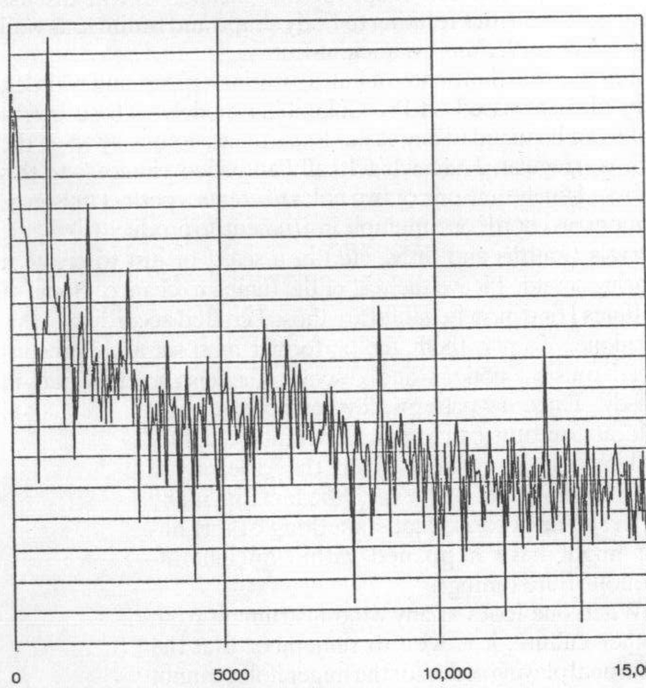
The construction of the airduct and its relationship to the edge are also important to the sound of the instrument. When sighted through the airduct, the edge should appear approximately in the middle of the window formed by the exit of the airduct, thus correctly positioning the edge in relation to the exiting airstream. This edge-to-airstream position affects the instrument's timbre and tone stability and is critical for extended range. Additionally, "a smooth flue (airduct) is important throughout the range and can make an all-or-none difference in the highest notes" (Robinson 1973:41)

The cultural concerns that inform construction of airduct assemblies in Pre-Columbian pipes and ocarinas are different from those of western instruments. Apertures of Pre-Columbian flutes tend to have an extended length, promoting tone stability and a soft, open timbre. As on many western instruments, airducts may be shaped, becoming smaller from the airstream entrance to the exit, thus concentrating the airflow. The maximum range potential of an instrument is seldom exploited. Most have a limited number of fingerholes and/or other modifications that affect timbre and restrict the range. A limited range requires less precision in the construction of assemblies. Yet, it is clear that these flute makers had all necessary skills at their fingertips. This is especially evident in an examination of the wonderful multiple flutes. Such instruments need components that respond similarly to changes in air pressure. Thus each part requires similar edgetone assemblies and therefore require great skill in construction.

FIGURE 5: Spectrum analysis of two ocarinas.
FFT, hamming window; sampling rate: 30,303 samples/second, monophonic, 12 bit.
Analysis by Roger Kendall, UCLA Dept. of Ethnomusicology.



A (above) Aperture proportions: 1L : 4W



B (above) Aperture Proportions: 2.5L : 1W

APERTURE FRAMES AND HOODS

Some ancient flute makers modified apertures on pipes by building up clay around the aperture into frames and hoods (Fig. 6). The addition of clay does not reduce the aperture area. Crossley-Holland (1980) refers to these instruments as "framed flutes," and observes that they are found exclusively in the zone surrounding Colima. However, according to Franco, vibration (or hooded) flutes are also found in Veracruz (1971:19). I have adopted the term "frame" to mean a build-up of clay into a straight wall around two or three sides of the aperture. Within limits, frames flatten the pitch. If the edge is close to the surface, it focuses the tone by preventing the air

from dispersing too quickly. As Crossley-Holland notes, when the flute is played outdoors, these walls also protect the airstream from interruption by air currents.

A hood on a pipe forms an awning shape around and over the aperture. It deflects escaping air back into the exiting air stream, causing perturbations and affecting the pipe's partials. The effect is more pronounced on pipes that have narrow bores (which generate stronger partials.) As the top of the hood is moved closer to the aperture, the sound becomes reedier, then raspier and more interrupted until it ceases altogether as the aperture becomes blocked. A hood can make the second octave impossible to play or playable only with great force. By affecting a pipe's partials, hoods manipulate timbre. Minute changes in construction can make a great difference in the tone.

In performance, small shifts in air pressure can greatly change the timbre of a hooded pipe, seemingly emphasizing various partials in the tone. As noted above, range is limited. These pipes can produce louder tones than those without hoods, but require more air pressure. The technique of circular breathing is readily achieved on these hooded pipes.

If a frame is constructed around the aperture of an ocarina, the pitch is flattened. The amount of pitch alteration depends on the height of the from walls (or hood).[3] Because an ocarina cannot overblow useable partials, a hood has a limited effect on the instrument's timbre.

FLUTE BODY SHAPES AND TUNINGS

A thorough discussion of Pre-Columbian scales and tunings is beyond the scope of this article. I will discuss aspects of acoustics relating to body shape and tunings, as well as some observations on ancient flutes.

I have made thousands of flutes, ocarinas, pipes, and whistles, many of them based on Pre-Columbian models. These instruments can be tuned to any scale. Sometimes, especially when the form is irregular, I use what I call "amplified chance." In this method, I finely tune one or two holes to create a perfect unison or harmonious chords on a multiple instrument, to produce harmonic intervals (fourths and fifths, etc.) in a scale, or just to create a pleasing sound. I leave the rest of the tuning to chance. Some of the flutes I find most beautiful are those I crafted according to this technique. To play them, the performer must set aside preconceived musical notions and discover the instrument's built-in melody. Fingering patterns, rhythmic phrases, and melodic contours can remain constant from flute to flute. It is possible, given the diversity of Pre-Columbian flute types and the fact that many are irregular in form, that something of this nature might have happened within ancient indigenous flute tunings.

When one looks at any wind instrument from another culture, it is wise to remember that the traditional playing order for the finger holes cannot be determined from an examination of the instrument alone. The scale that results from that order may therefore never be known. This problem is thoroughly discussed by Dale Olsen (1986).

However, acoustic principles for the functioning of wind instruments are constant regardless of culture. Thus, the length of a tube primarily determines its fundamental pitch; the size and position of the fingerholes on a tube dictate the scale. Olsen suggests the "reverse western method" (and the "reverse Warao method") for testing fingering systems of flutes (1986:12). This method involves beginning with all holes open and closing them sequentially from the distal end (farthest from the edgetone assembly). Yet, depending on their number, opening and closing the fingerholes closest to the distal end will make minute or no tonal differences if the holes closer to the assembly remain open. Therefore, this test system may not be useful.

Further, as Linda O'Brien noted about the San Lucas Band in Santiago, Atitlan: "Only the contour of the melodies and accompanying parts has endured unchanged. This phenomenon of changing the rhythm and tonal system while preserving contour has been observed to characterize Indian music in other areas of Guatemala" (1972:21). This understanding of melody is very different from that of western cultures. If true of the ancient aboriginal cultures, then particular pitches and intervals produced by a flute may not have been very important to indigenous concepts of music.

VESSEL FLUTES

With their enclosed body forms, vessel flutes come in a wide variety of shapes. They cannot be overblown to the octave range above the sounding pitch. Each fingerhole or combination of holes serves a unique tone, sometimes demanding complex cross-fingering patterns for a given scale. In western terms, the range is limited, typically being contained within a major tenth or less.[4] The greater the desired range of the vessel flute, the more precise the construction of the assembly and body must be.

Body shape strongly influences the partials or overtones of vessel flutes. Some irregular forms seem to produce partials which interfere with the mid to upper notes of an octave, causing squeaks or blocking the sound altogether. The placement of the edgetone assembly can also be important. When an aperture is placed in the middle of a fat tubular shape, the instrument will function like a vessel flute. If placed on one end, partials may develop that interfere with the scale (Fig. 7). If the physical shape of the vessel flute is of primary importance, problems can be avoided by restricting the instrument's already limited pitch range. Typically, Pre-Columbian ocarinas have four or fewer fingerholes and play in a range of a sixth or less, although there are exceptions.[5] Harcourt (1941) states that vessel flutes received their highest degree of development in Pre-Columbian Costa Rica and Nicaragua,

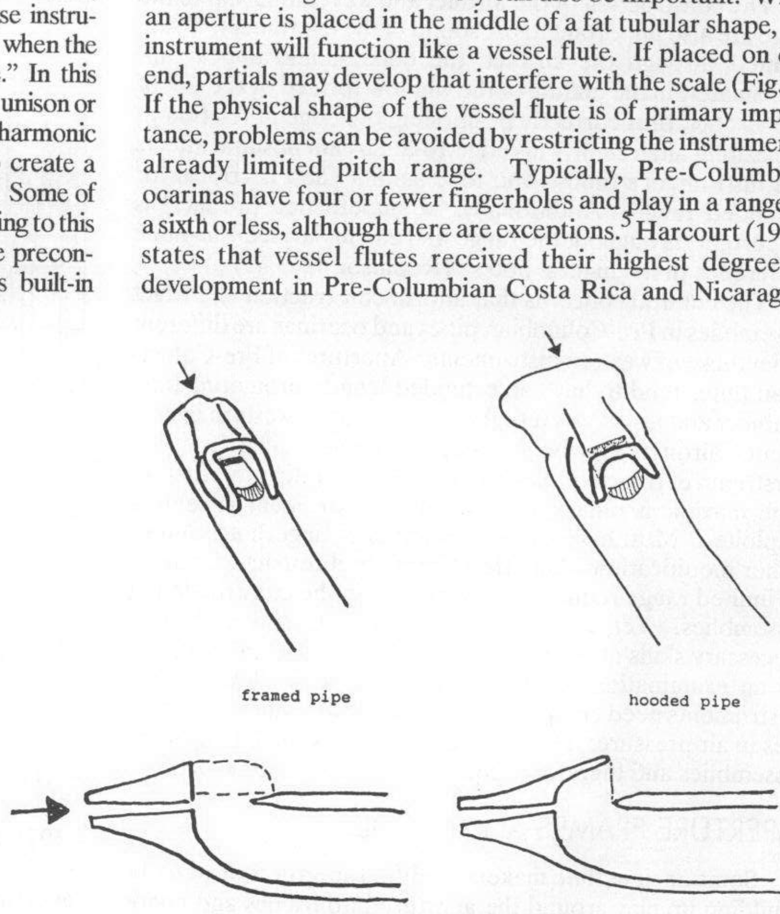


FIGURE 6: Aperture frames and hoods

where instruments have been found with four holes that play six to eight tones with a range of more than one octave.

The vessel flute's fundamental pitch is determined by the internal volume of the chamber, the area of the aperture and the height of aperture walls (including that of the instrument's body – the clay, gourd etc.) Within limits, these factors interact. A large ocarina with a large aperture might play the same fundamental pitch as a smaller ocarina with a small aperture. In general, the former can be played more loudly than the latter. Additionally, the pitch of a vessel flute is extremely sensitive to air pressure. The fundamental pitch can be tuned in one of three ways: 1) by making a small hole anywhere on the body before firing, to be tuned after firing; 2) by adding vertical walls or a frame around the aperture before or after firing to flatten the pitch; and 3) by enlarging the aperture, which raises the pitch.

For vessel flutes, the position of the fingerholes is relatively unimportant. Primarily, it is their size that determines pitch. However, irregular internal body shapes can cause hole placement to affect the relationship between hole size and pitch. The pitch rises as the combined open area of aperture and fingerholes increases. To tune a scale, the fingerholes are cut larger, in order to raise the pitch; smaller to lower it. Before firing, clay can be added or removed; after firing, glue, wax or rosin can be added inside the holes, or the hole can be filed out. Clay flutes can be played before firing and fine-tuned afterwards.

To maintain the same interval distance from note to note while opening the holes one by one in a predetermined order, the size of each hole must progressively increase the total open area – fingerholes and aperture – by a given "percentage." This total open area increases with each additional hole. Therefore, to maintain that percentage, the size of each fingerhole when opened must be larger than previously opened holes. To yield this type of scale, the pattern requires holes of distinctly varying sizes. This concept is commonly found on European folk ocarinas with western diatonic or chromatic scale.[6]

If fingerhole sizes are approximately equal, one hole will sound the approximate same pitch as any other. Opening any two holes will also sound the same approximate pitch as would opening any other two, although small differences in hole size and therefore pitch may be exacerbated. If the holes are played sequentially one by one (or two by two), the interval between notes will decrease as the total open area increases. The largest interval occurs between the fundamental tone and that of any first hole. Thus, a sense of diminishing interval when ascending the scale characterizes the melodies of this type of vessel flute. Crossley-Holland proposes a averaged scale of minor 3rd, major 2nd, major 2nd, minor 2nd for four-holed ocarinas of West Mexico, if the holes are played sequentially, one by one, beginning with any hole (1980:19). This abstracted scale, when ascended, creates a sense of diminishing intervals, especially if the first major 2nd of the sequence is perhaps a major-2nd-plus. My own informal examination of thirty-four four-holed ocarinas from this area also indicates a tendency towards holes of the same approximate size.[7] Perhaps these ancient flute makers placed greater value on holes of roughly equal size than on a particular scale. Or perhaps they simply used the same stick to cut fingerholes for on ocarina. Perhaps this flute construction practice generated a scale type in the sense proposed by Crossley-Holland.

TUBULAR FLUTES

In tubular flutes, the fundamental pitch is primarily determined by the length of the tube, although the aperture area also has a limited effect on pitch. The internal diameter or bore of the tube and its uniformity influence an instrument's partials. A flute with a narrow bore in relation to its length will have strong upper partials; a wide bore will emphasize lower ones. The position and shape of the assembly also affect the partials and timbre of the instrument.

To tune a flute's fundamental tone, a tube is trimmed until the desired pitch is obtained. Because it has linked tubes of differing lengths, a panpipe can play multiple tones. In effect, fingerholes progressively shorten a tube, creating the multiple tones of panpipes within a single tube.

In tuning tubular flutes to the desired scales, the position of the fingerholes along the tube and their size are critical. Hole size and position also affect the ease of performance by determining finger placement. Additionally, the size of a fingerhole modifies the tone's timbre and loudness, and to a diminishing extent, that of subsequent scale tones. To produce a pitch, a fingerhole must be cut within specific boundaries. At one extreme is a hole with the diameter of the bore – the equivalent of cutting the tube at that point. A tubular flute with holes this large will produce a scale with tones of relatively similar timbre. However, the instrument's body will be structurally weak and the holes will be too large for the fingers to cover. If a smaller hole is to yield the same pitch, it must be positioned closer to the edgetone assembly. If it is too small, the hole will merely squeak when opened. Between these limits a hole is positioned, producing a scale according to the principles of pitch, playing comfort, and relative ideals of consistency in timbre and loudness from note to note.

To maintain an interval relationship from note to note while opening holes sequentially in performance, the distance between and/or the size of the holes must be decreased as they are cut closer to the edgetone assembly. Western tubular flutes with diatonic and chromatic scales generally follow this pattern. Even opening holes two by two will produce consistent intervals. Thus, opening any two adjoining holes of a European wooden transverse flute (the first and second; second and third, etc., counting from the distal end) will approximate a major or minor third.

Kathleen Schlesinger, in **The Greek Aulos** (1939:16), used evidence from flute construction practices in which the diameter of fingerholes and their spacing remain constant in order to determine what she considered to be early scales. When playing flutes with these scales, the

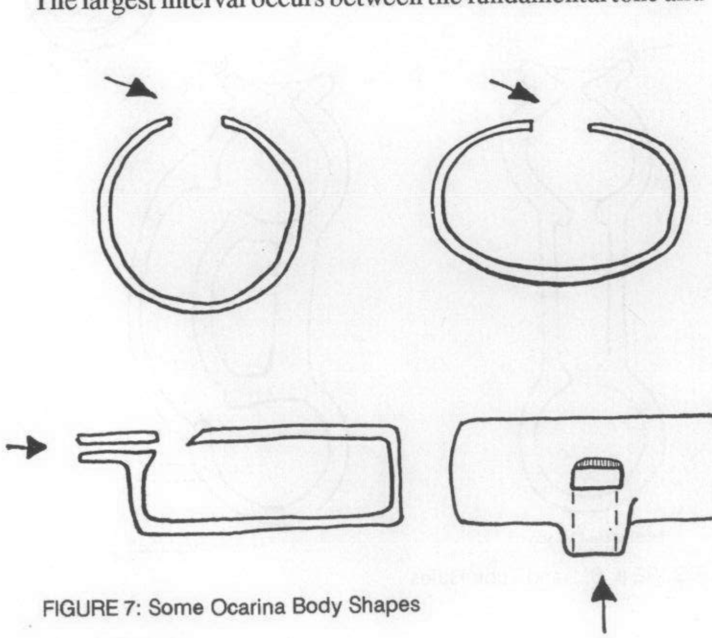


FIGURE 7: Some Ocarina Body Shapes

size of intervals increases as the fingerholes are opened sequentially one by one or two by two beginning with the distal end (note the differences between these and vessel flute scales with holes of equal dimensions). Such scales may contain pure fourths and fifths, in addition to a variety of other intervals.

Again, perhaps construction practices generated a scale type, rather than a scale generating construction practices, as on western flutes. A pre-Classic Colima pipe (West Mexico) found in a private collection has four holes with diameters ranging from 6.0mm to 6.2mm. The measurements from the distal end to the midpoint of the first hole and then to the midpoint of each successive hole are 25.6mm, 20.7mm, 21.2mm, and 21.9mm. The intervals of this flute increase as holes are opened successively without deviating from the abstracted Colima scale, minus microtonal differences, as described by Crossley-Holland (see below).

The West Mexican pipes typically have four fingerholes. According to Stevenson in **Music of Aztec and Inca Territory**, "the more usual number of holes even in Mayan flutes of the best period must have been the four implied for the flute in the Dresden Codex ... Aztec flutes, wherever found, obey the four-finger rule ..." (1968:80). Crossley-Holland proposes two abstracted scales from West Mexico: from Colima (200 B.C.-A.D. 500), minor 2nd, minor 2nd, minor 2nd, minor 2nd; and from Michoacan (A.D. 900-1500), minor 3rd, major 2nd, minor 3rd, major 2nd. He further states that "the important point does not seem to focus in microtonal considerations, and these may even obscure it. It is rather that despite variations shown by individual instruments of a type, even relatively wide ones, such variations remain *inessential*" (1980:19). Perhaps this interpretation is related to O'Brien's (1972) observation of characteristic indigenous music in Guatemala, which preserves melodic contour while changing rhythm and tonal systems.

For Franco (1971:19), "the highest musical achievement of Mesoamerica in Classic times was the harmonic multiple flute." According to Charles Boiles (1965), the importance of these multiple pipes, in particular the Gulf Coast triple pipe of Tenenexpan, is that they present evidence of polyphony in early indigenous traditions. In addition, they demonstrate knowledge and use of the harmonic series in their construction and tuning, and suggest that the psycho-acoustic phenomenon known as "combination tones" might have been used to obtain their refined tuning (1965:215-217). Other multiple whistles, ocarinas, and pipes from many Pre-Columbian cultures produce strong combination tones, such as small double figure pipes from West Mexico; double whistles and pregnant female figures from Costa Rica; and a post-Classic Maya double ocarina from Honduras.

Having played Pre-Columbian pipes from many cultures, I have found that only a few play the harmonic series when overblown. Those that do play them do so impeccably. If there is a second octave, the scale in this range is usually different from that of the first. This lack of concern with the harmonic series may reflect an absence of stringed instruments in these cultures. Pre-Columbian aerophones celebrate the delights of diversity in shape, scale, and timbre. As noted in Olsen's work, intervals are not fixed from instrument to instrument, although fingering patterns may be. Timbre may vary from note to note and from instrument to instrument. No scale is standard in European terms, although many cultures seem to value certain "melodic contours" for particular flute types, reminiscent of the findings of O'Brien in Guatemala, and the abstracted scales proposed by Crossley-Holland.

By contrast, within European art music traditions, the mathematical order within the harmonic series is held as an ideal. This ideal, which theorists have attributed to the ancient Greeks, determines European perceptions of intervalic structures and tonal relationships. Construction practices refine the body of an instrument to maximize the potential for the harmonic series. On flutes, these practices include a smooth, uniform bore and the design and position of the assembly. Airduct assemblies tend to have apertures with a small length and a smooth, shaped airduct. Most flutes play two or three octaves with a more or less standard scale, relatively constant timbre and loudness from note to note, and a brilliant tone.

HYBRID FORMS: BALL AND TUBE FLUTES

Distributed throughout the Pre-Columbian world are flutes found nowhere else in the world which combine globular and tubular forms to create instruments that are neither flutes nor ocarinas (Fig. 8). From Nicaragua and Honduras come ball and tube flutes with two or three chambers of roughly equal size connected by a large hole. Franco states that they were "the most common melodic instrument in Veracruz," and were "much in use during Maya-Toltec times in Tabasco, Chiapas, and the Yucatan Peninsula" (1971:20). In West Mexico instruments of the Classic period, a hollow tube, either curved and/or straight, connects two spheres. All have blowhole assemblies with a lip rest similar to that of a western bass flute, which extends upwards along the side of the blowhole, forming a large edge which guides the airstream from the player's lips. Specific tones can be achieved on these flutes, but because of their irregular shape, each fingering position seems to overblow its unique series, as if every ball and tube flute had a built-in melody for a scale. With cross-fingering, many tones can be produced. In some fingering positions, two partials can easily be blown simultaneously, creating unique split tones. As tuning cannot be controlled to a great extent, the "melody" will vary from flute to flute.

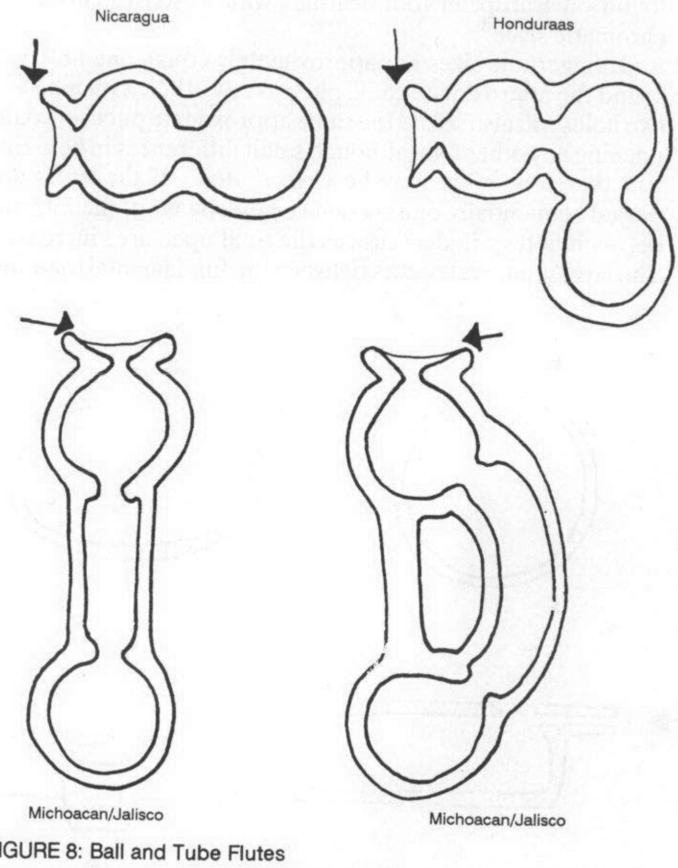


FIGURE 8: Ball and Tube Flutes

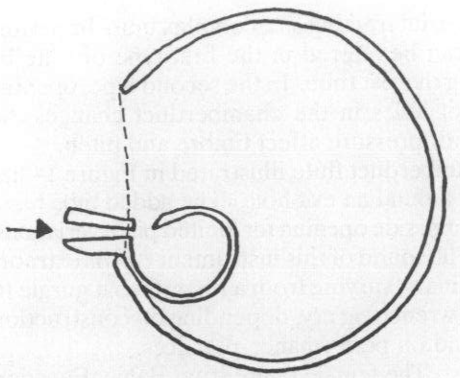
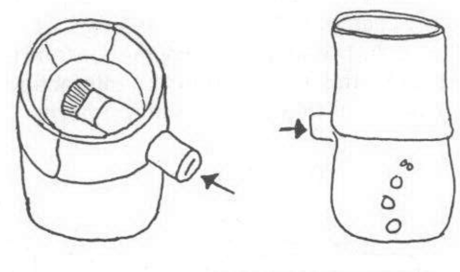


FIGURE 9 (left): Pitch jump whistle: whistle in chamber.

FIGURE 10 (Center and right): Pitch jump ocarinas: chambers around aperture.

Center drawing by Mendoza, from "Tres instrumentos musicales prehispanicos"



Right: Whiffle ocarina

Drawing by Rawcliffe

HYBRID FORMS: PITCH JUMP WHISTLE AND OCARINAS

There are three basic types of wind instruments in which multiple chambers share a single aperture: a whistle placed inside a larger chamber; a chamber placed around the aperture of a whistle or ocarina; and two whistles, one with an airduct, positioned with their apertures directly opposite, both surrounded by a third chamber. All have a unique sound event in common: the pitch jumps from a lower to a higher tone with an increase in air pressure. These instruments are unique to the Pre-Columbian world and deserve further study.

When a whistle is placed inside a chamber, the two volumes share a single airduct assembly (Fig. 9). Examples of this are found in a Remojadas funeral statue in the Museum of Cultural History at UCLA, and a Veracruz mask-like whistle, at the University of Jalapa, Veracurz. My own experiments with sound production in these instruments leads to the hypothesis that the pitch of the generating whistle must be at an appropriate frequency to activate one of the secondary chamber's partials. Therefore, a specific set of tones (or whistles) will work for a given volume in the secondary chamber. Acoustical adjustments can be made by varying the size of the opening of the secondary chamber.[8]

When a secondary chamber is placed around the aperture of a ducted chamber (Fig. 10), the instrument seems to work best if the chambers are approximately equal in size. Franco includes a pitch jump whistle of this type in his discussion of wind instruments from Veracruz (1971:20). Vicente T. Mendoza (1947:76) also includes one of these whistles in his depiction of the evolution of Pre-Columbian wind instruments.[9]

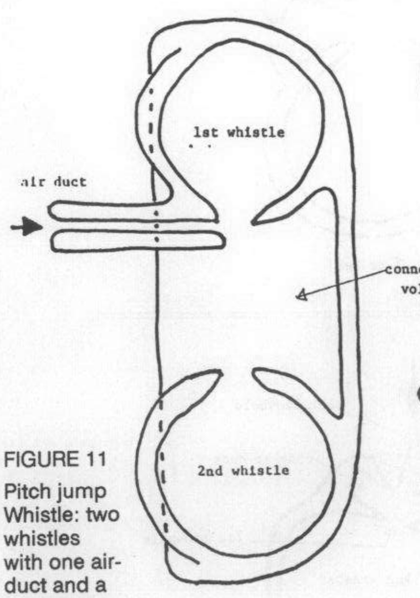
I developed a pitch jump instrument inspired by Mendoza's drawing that I call a "whiffle" ocarina. In this piece, the primary chamber includes tuned finger holes and the secondary chamber is open like a cup. To play it, one hand slides over the large open end, opening and closing it. The other hand fingers the holes. In performance, there is a complex interaction between the chambers that depends largely on the air pressure and on each chamber's total open area.

A further variation of chambers sharing a single airduct assembly is found in a Classic-era Bahia Bird whistle (Ecuador) and a Maya bird whistle (both in private collections). Two whistles of a similar size have their apertures placed directly opposite from each other, surrounded by a third open chamber (Fig. 11). An airduct activates one chamber; and, as discussed above, the sound jumps from one pitch to the other, depending on the air pressure. Within limits, decreasing the open area of the surrounding chamber with the hand or finger lowers the pitch.[10]

CHAMBERDUCT FLUTES

The use of a chamberduct assembly (Fig. 12) is unique to the Pre-Columbian world and deserves further study. According to Franco, instruments using this system, which he calls "air-spring aerophones," can be traced to the Olmec cultures of the eighth century B.C.E. At the heart of this system is a small chamber in which two opposing holes direct the air in and out, as in a tea kettle's whistle or a Brazilian mouthwhistle. In the chamberduct system of sound production, the two critical factors are the size of these opposing holes and the distance between them. Another chamber can be constructed around one of these blowholes, and additional finger or exit holes can be added to the chamberduct. In this case, the hole through which the air first enters must be slightly smaller than the second hole. This factor interacts with the distance between the two blowholes and the relationship between the sizes of the two volumes in a manner not yet completely understood. The resulting timbre sounds on a continuum from raspy air noise to rich, reedy tones. Changes in air pressure alter pitch and timbre. With two exit holes of different dimensions, there are three fixed tones (excluding half-holing).

Three interrelated volumes are found in Figure 13. There are two types: an exit tube or a chamber can be added around an exit hole of the chamberduct, or a mouth tube can be added



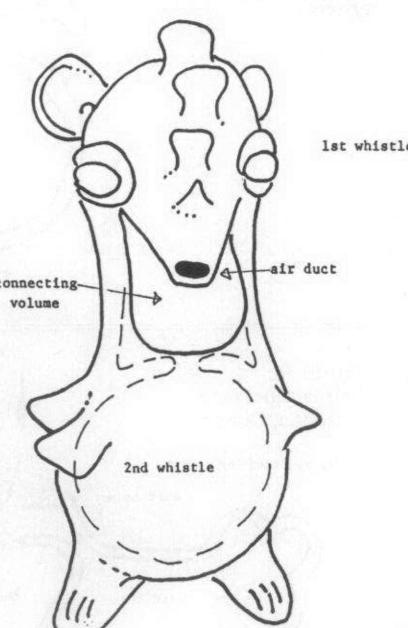


FIGURE 11 Pitch jump Whistle: two whistles with one airduct and a connecting chamber.

Jaina, 300 - 900 AD

in front of the first blowhole. In addition to the other critical factors and conundrums of this system, the length or size of the additional tube or chamber must be proportional to that of the other chambers. Increasing its length or size may lower or raise the pitch. For some tube lengths, the tone is blocked or unstable. Possibly, this results from the interaction between the tube's partials and those of the entire system. These chambers are acoustically coupled, interacting as a complex unit. In performance, the pitch can be altered in the first type of flute by opening and closing the exit tube. In the second type, opening and closing the exit holes in the chamberduct changes the pitch. Changes in air pressure affect timbre and pitch.

The Olmec chamberduct flute illustrated in Figure 14 has an exit tube placed around an exit hole. The added tube has a large side opening for limited pitch variations. The sound of this instrument type is extraordinary, varying from a raspy throat gurgle to a wrenching cry, depending on construction and on performance practices.

The female figure from Bahia, Ecuador, is a double flute with mouth tubes placed around the first blowholes leading into their respective chamberducts (Fig. 15). My first clues to the internal construction of these flutes came from studying shards in the Field Museum of Chicago. I did not realize then that the size of the mouth tube would significantly affect the sound production of the flute. This omission caused much consternation when I later tried to construct the acoustical innards of this instrument. As stated earlier, the timbre is raspy and wonderful. The pitch can be altered with the two exit holes placed in the front and back of each instrument within the figure; the individual flutes each have three pitches. That these flutes are doubled is an added delight for performers.

Four interrelated volumes integrated these three volume systems, linking a mouth tube, chamberduct, second chamber,

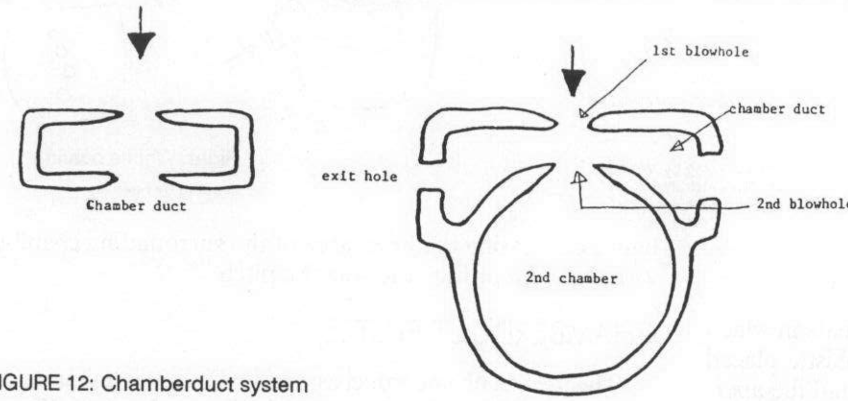


FIGURE 12: Chamberduct system

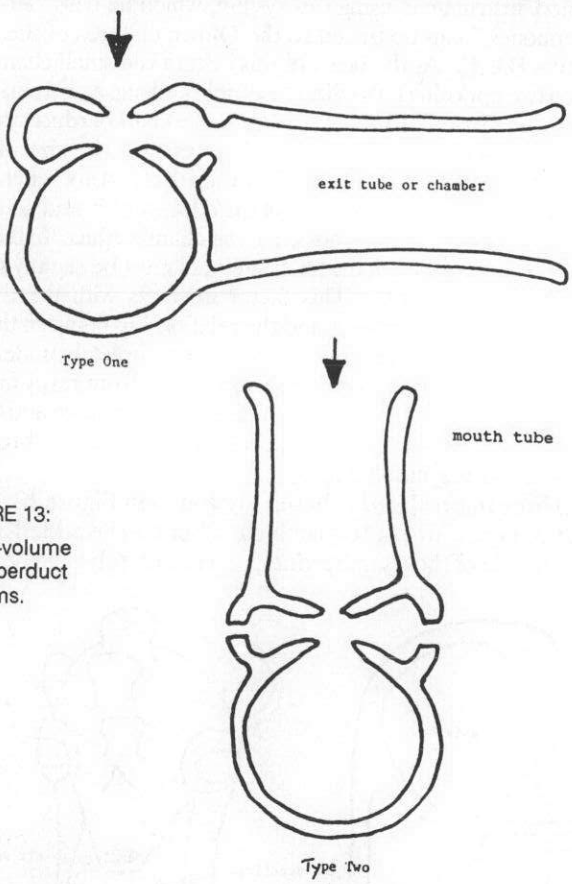
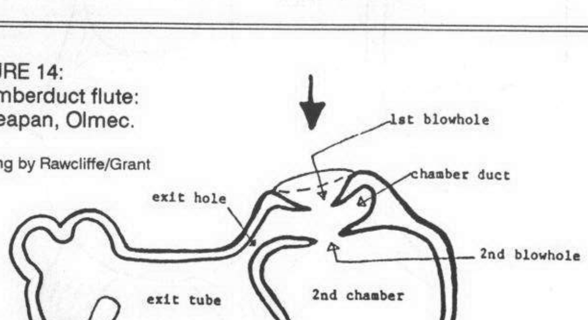


FIGURE 13: Three-volume chamberduct systems.

FIGURE 14: Chamberduct flute: Tzoteapan, Olmec.

Drawing by Rawcliffe/Grant



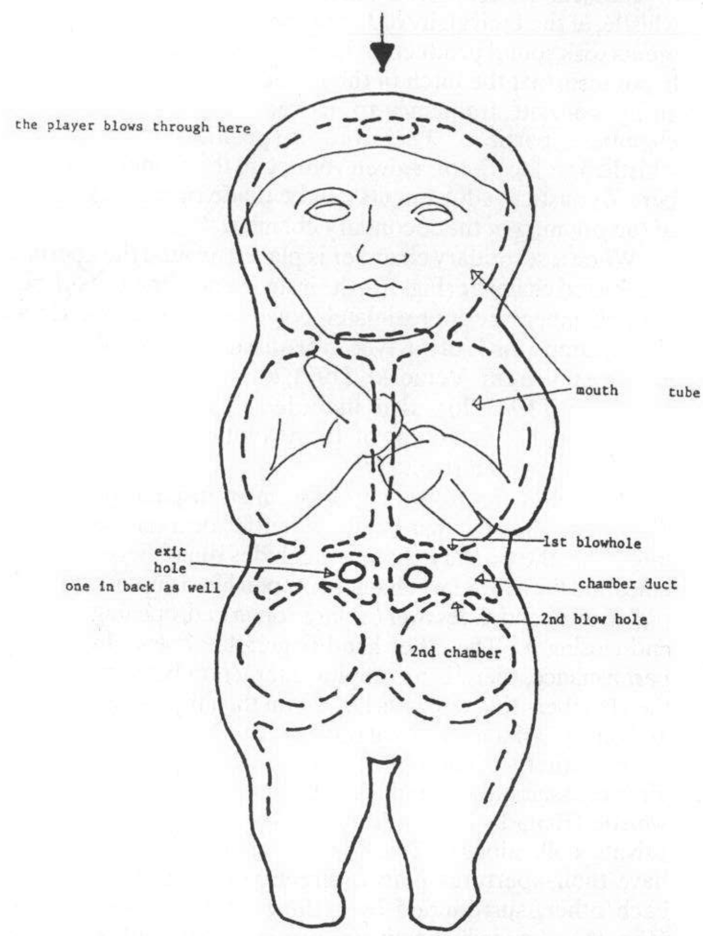


FIGURE 15: Double chamberduct flute: Bahia, Equador, 400 BC - 400 AD.

and exit tube (Fig. 16). All chambers must be proportional to each other. Sometimes, lengthening the mouth tube lowers the pitch to a greater extent than a similar increase in the exit tube. The exit tube can have fingerholes, although the position of the holes does not affect the pitch to the degree that it does on tubular flutes and pipes. This illustrates the acoustic coupling of the chambers and the complexity of these systems once again. The construction of this type of flute determines the spectrum of timbral possibilities, which varies according to the respective sizes of the two blowholes, their distance from each other, and the size relationship of all volumes. The timbre moves along the same splendid continuum, from raspy air noise to reedy tones, and is affected by air pressure changes. There is no second octave.

The Maya chamberduct (goiter or air-spring) flute has four inter-connected volumes (Fig. 17). These instruments usually have one or two fingerholes. Figure 18, a shard of what seems to be a Mayan chamberduct flute from Lagartero, Chiapas (circa 800 A.C.E.) documents a possible variation of the system described above.

CONCLUSION

In short, the acoustical thinking and construction techniques of Pre-Columbian flute makers demonstrate a high level of sophistication. The products of both individual and collective acoustical exploration, these impressive instruments must have been important to their creators and their societies. According to John Nyberg, "the degree of technical perfection shown by the creators of these musical instruments indicates that they were specialists" (1974:92).

What stands out in these Pre-Columbian flutes is their diversity of form, timbre and partials, and tunings. Perhaps these instruments were meant to be played alone or accompanied with unpitched instruments. Perhaps ensemble pitch was organized around single related tones. Perhaps melodic contour and/or timbre was valued more than either pitch or the kind of tonal organization we think of as "scales." Certainly, pitch relationships were organized in ways that challenge "scientific" acoustical principles developed by Europeans.

The tonal range of Pre-Columbian instruments does not seem to have been important. Ocarinas have a small range. A hood on a pipe limits its range. Many of the most complex and time consuming technical innovations resulted in instruments of restricted pitch but rich timbre: chamberduct flutes, pitch jump whistles, ball and tube flutes, and hooded pipes. Some innovations in construction served to increase loudness and/or to modify timbre towards increased reediness or raspiness. Yet a great number of these complex flutes remain relatively unknown, absent as they are from standard instrument classification systems.

Because of the plasticity of clay and the status of ceramics as a major technology, this medium may have facilitated complexity in flute forms, many of which are an agglutination of rounded forms. Chambers were combined with other chambers and/or

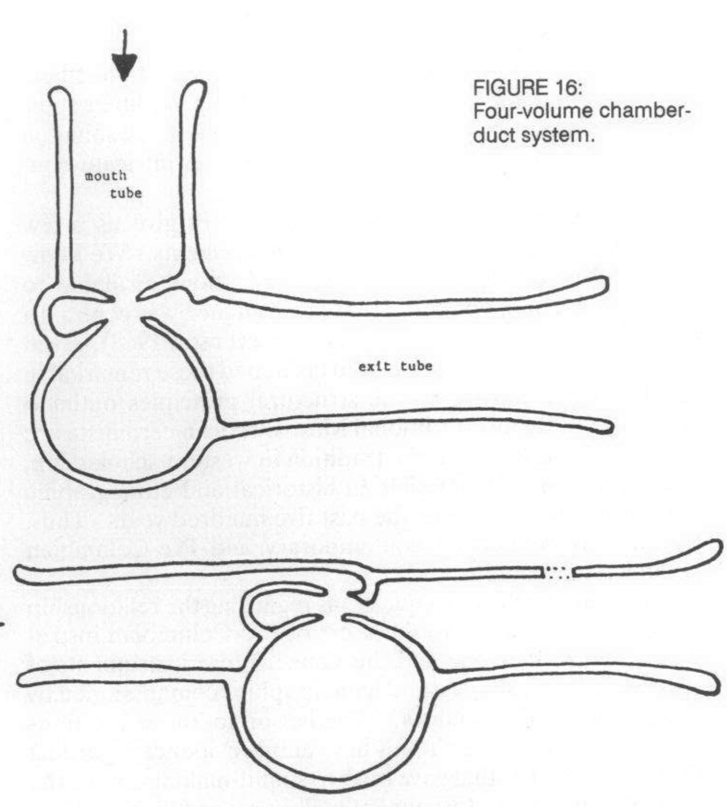


FIGURE 16: Four-volume chamber-duct system.

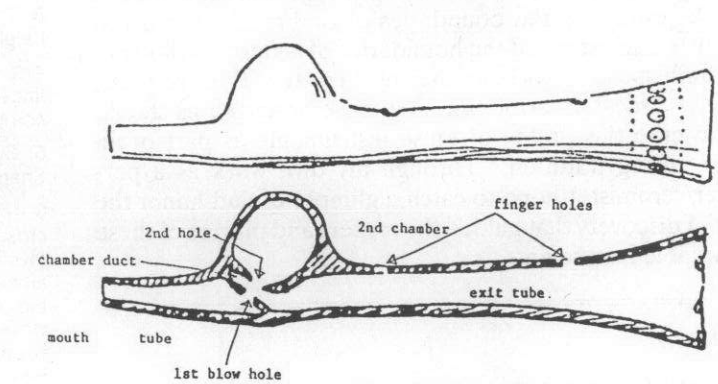
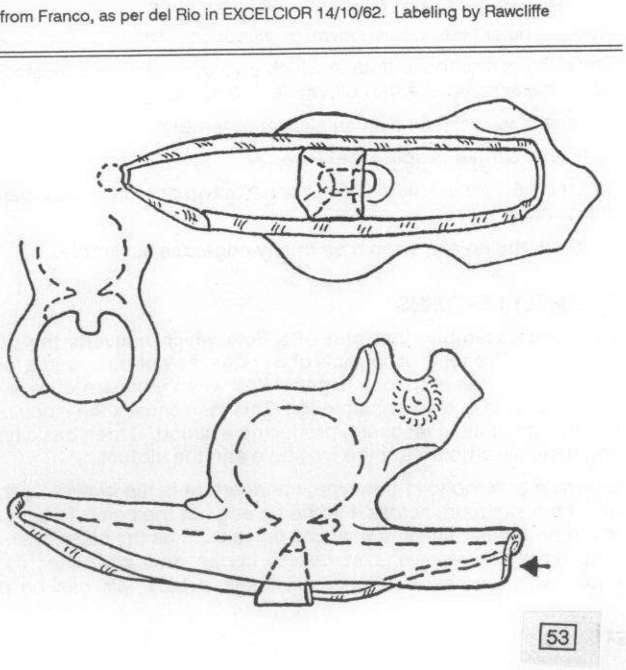


FIGURE 17: Chamberduct flute: classic Mayan goiter flute.

Drawing from Franco, as per del Rio in EXCELCIOR 14/10/62. Labeling by Rawcliffe

FIGURE 18: Possible chamber-duct shard, Mayan from Lagertero, Chiapas, ca. 800 AD.



tubes. Whistles were placed inside vessels and chambers placed around apertures. Frames and hoods modified apertures on pipes. Chamberduct assemblies produced sound in tubes and other chambers linked together in intricate configurations.

Codexes and scholarly European studies give us a few clues about the performers of these instruments. We know that music was one of several specializations available to Pre-Columbian peoples and that performance was central to civic and religious power structures (Stevenson 1968). Even less is known of the ceramists who fashioned these remarkable aerophones according to the structural principles outlined above. Today, most traditional Mesoamerican ceramista are women and, as has been the tradition in western scholarship, women are virtually invisible in historical and ethnographic chronicles produced over the past five hundred years. Thus, the threads connecting contemporary and Pre-Columbian ceramists are tenuous.

We are left with many questions regarding the relationship between the makers and the users of Pre-Columbian instruments. Were they one and the same? Were instruments of specific timbres, shapes, and iconographies commissioned by patrons or ritual specialists? Whether or not these questions are ever answered, we already have ample evidence regarding the creative matrix that gave birth to sound-making among the ancient Americans. Instrument makers placed high value on experimentation with timbre and apparently delighted in the infinite possibilities generated by their ingenious discoveries. And, by extending the boundaries of timbre, these musical scientists also extended the boundaries of acoustical thought. The sophistication and intricacy of these traditions requires dense technical descriptions. But these descriptions should not obscure the vitality of these instruments as part of an ancient living tradition. Through my own work as a performer/ceramist, I hope to catch a glimpse of and honor the spirit of discovery that guided the makers and players of these remarkable instruments.

APPENDIX

The following definitions are used with this essay:

INSTRUMENT BODY TYPES:

Flute: any instrument in which a column or volume of air is activated by an edgetone assembly, either airduct or blowhole.

Pipe: a tubular flute, either conical or cylindrical, with an airduct assembly.

Vessel flute: a globular flute in which a volume of air is activated by an edgetone assembly, either blowhole or airduct.

Ocarina: a vessel flute with an airduct assembly.

Whistle: a simple (single-tone) flute.

Ball and tube flute: a flute which connects two or more hollow balls with one or more tubes.

Aperture: the hole or open area of any edgetone assembly.

ASSEMBLY FEATURES:

Edgetone assembly: that part of a flute which converts the player's airstream into a tone. It consists of an edge, an aperture, and a focused source of air. An edgetone is generated when a stream of air vibrates back and forth across a sharp edge. This then causes the air column or volume of a flute to resonate, producing a sound. Three basic types of edgetone assemblies are the blowhole and the airduct.

Blowhole assembly: in this type, the aperture is the blowhole; the lips direct the airstream across it to the far edge of the hole. Two types are found on tubular flutes: transverse flutes such as the classical western flute have crossblown assemblies; **kenas** and **shakuhachis** have endblown assemblies. On vessel flutes, a blowhole can be placed almost anywhere on the body.

Airduct assembly: has a slot or windway to direct the airstream from the lips across the aperture to an edge. This assembly is used for ocarinas and pipes.

Chamberduct assembly: has a hole to direct the airstream across a small chamber to another hole.

ACOUSTICAL FEATURES:

Partials: simple tones that combine to form a complex tone. The lowest such tone is called the fundamental. The partials determine in part an instrument's characteristic tone color or timbre.

Harmonic series: a special class of partials with a simple mathematical relationship to each other as follows: the fundamental frequency or f, a frequency twice that of the fundamental (2f), 3 times the fundamental (3f), 4f, 5f, etc.

NOTES

1. All drawings are by Jim Grant, except as noted. I want to thank the people who helped me with this article: Jim Grant, who was generous with his support; Sue DeVale, who was generous in her critiques and suggestions; Peter Crossley-Holland, who gave me access to his collection; Bob Chiles, of the UCLA Museum of Cultural History; Robert Kendall at UCLA, who realized the computer analysis of ocarina spectrums; Linda O'Brien, who read this paper in draft form; and Carol Robertson, who provided the opportunity for me to participate in the Smithsonian symposium on "Musical Repercussions of 1492," without which this paper would not have been written.

2. Many aspects and manipulations of Pre-Columbian instruments parallel techniques used by organ voicers.

3. This interrelationship also occurs on a Helmholtz resonator when the height of its neck is increased.

4. Chuang, Pen-Li (1972) describes a Japanese ocarina that has twelve fingerholes and plays an octave and a sixth above. This is the largest compass I have heard of to date.

5. By contrast, Chuang, Pen-Li (ibid.) states that by the latter part of the Shang dynasty, some **hsun** had five holes and played an octave or more.

6. For example, my smallest ocarinas use six finger holes and two cross-fingerings to produce a diatonic 9th. Each hole is tuned individually to produce the following approximate intervals when opened alone: major 2nd, major 3rd, minor third, neutral third, 5th, and 4th. With the other five holes opened, the hole that produces a 4th with all holes closed, now plays a major 2nd. Chuang, Pen-Li (ibid.: 204-205), discusses an eight-holed **hsun** that he made in order to play a chromatic 10th. Hole sizes vary from 3.3mm to 7.7mm. The same fingering pattern for the first four functionally similar holes is used to play the chromatic 6th as is used on my own ocarinas.

7. However, two holes are sometimes equal while the other two holes are equal to each other but different from the first pair; or three holes are equal while one is different.

8. To simulate the effect, blow whistles of various sizes into chambers such as cups; vary your air pressure until the tone jumps. Try partially covering the large opening of the chamber with your hand or face. The pitch of the primary whistle is usually flattened when placed into the secondary chamber.

9. Some of his other drawings do not work. One may be an attempt to depict a chamberduct flute.

10. I made an example of such an instrument with a moveable second whistle and determined that the interval between the tones increases as the distance between apertures decreases. By rotating the moveable whistle so that its hole is out of alignment with the ducted whistle's blowhole, only a single tone can be played, pitched between the two previous tones. Of course, as the second chamber in not being activated, the volume of the total system is diminished. The primary whistle now rests in a small chamber. However, unlike the whistle-in-a-chamber previously discussed, this instrument produces only one tone. In this case, size relationship of the two volumes, whistle and its surrounding chamber does not allow for the pitch jump effect to occur. Perhaps in this construction, the enclosing volume functions like the frame around an aperture described earlier, and merely flattens the pitch of the generating whistle.

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KITCHEN DRUMS

by C. Luc Reid

Kitchen Drums are my answer to the problem of inexpensive percussion. When I was a waiter years ago, we were assigned "sidework" to do when we weren't busy with customers. "Sidework" often involved lugging around large, plastic food-service tubs; boredom prompted me to thump on them. Imagine my surprise when I discovered that certain of these tubs have excellent tone. Mounted properly, I wondered if they could be used as drums.

Accordingly, I went to the largest restaurant supply store I could find and began thumping on all their plastic food service tubs (ignoring the stares I got from other customers). I selected seven different tubs for range of pitch and timbre, then collected a few minor pieces of lumber and constructed a frame. The tubs and the lumber together cost me about $25. I screwed the tubs upside down onto the frame and tried them out.

Thus were born Kitchen Drums.

Kitchen Drums may be played with mallets, hands, brushes, or even sticks, although sticks tend to make so loud and sharp a noise that I rarely use them. Mallets are perhaps the most useful; either the rubber-ball type or those with string-wound heads can be used. The drums can be played by hand to good effect, but as they are quite hard it is difficult to play them for a long time this way.

When selecting tubs for use, there can be no method preferable to going into a restaurant supply store and trying out every likely tub in sight. For my set, I bought two kinds of tubs: translucent white Rubbermaids and clear Cambros. The Rubbermaids provided an excellent duller sound, like a tambour or conga drum. The Cambros had a surprising ring, and sound a little like tablas in consequence.

I selected Rubbermaid tubs #2604 (3.5 quart), 2608 (8 quart), 2606 (6 quart), 2612 (12 quart), and 2618 (18 quart). The 8 and 18 quart tubs are quite deep, and their tone is that much fuller because of it.

To finish out the set I selected 12 quart and 6 quart Cambro tubs.

I constructed the frame from one 8-foot 2x4 and one 6-foot 1x2. I cut the 2x4 into 2 3-foot sections and 2 1-foot sections and the 1x2 in half. The two 1-foot pieces I nailed onto the ends of one 3-foot piece of 2x4, all with narrow side to the floor, forming an shape like the letter I. This is the base. I used the two lengths of 1x2 as supports, nailing them each about 6" away from the center of the base, one on each side of the base, so that they were about 1 foot apart, each with one end flush with the floor and the other sticking up 3' into the air. I then slipped the other section of 3' 2x4, the crossbar, between the tops of these two supports, so that it was exactly parallel to the 3' section of the base.

At this point the frame is complete, and can be sanded and painted or stained before attaching the drums.

I used a drill to make three holes in a triangle shape in each tub. When drilling, start about 4 inches from the top of the drum (that is, from the bottom of the tub). The triangles must be fairly small (less that 1.5" on a side) to accommodate the curvature of the tub.

I attached the drums, upside-down, to the crossbar using three 1", phillips-head wood screws per tub. In attaching the drums, care must be taken that they will sound properly once all are mounted: The screws should be tight, so that the drum does not shake when struck. No two drums should be touching, and the tops of the drums should be level unless some other arrangement is more comfortable for the drummer. None of the drums should be within half an inch of either of the supports, as this will cause a buzz. When this is done, the set is complete. I mounted my two Cambros and the largest Rubbermaid on one side of my crossbar, and the four smaller Rubbermaids on the other. This is probably the simplest configuration, although not necessarily the most effective. Certainly anyone with elementary carpentry skills can devise and construct a frame to accommodate both his or her particular needs and the tubs used.

It is possible to construct a set of portable Kitchen Drums. Before drums

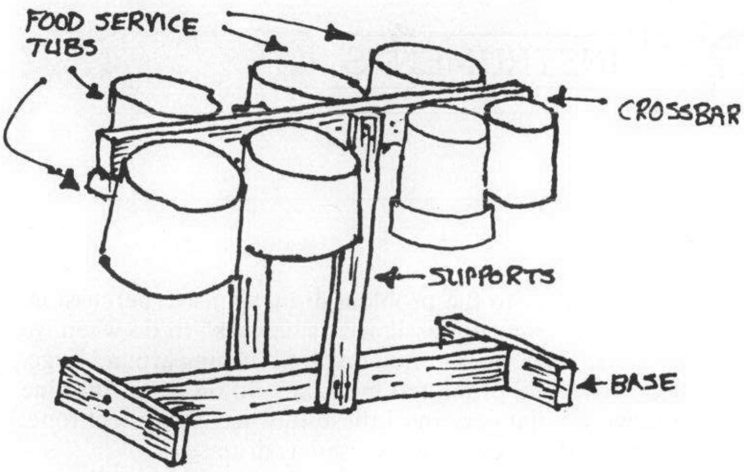
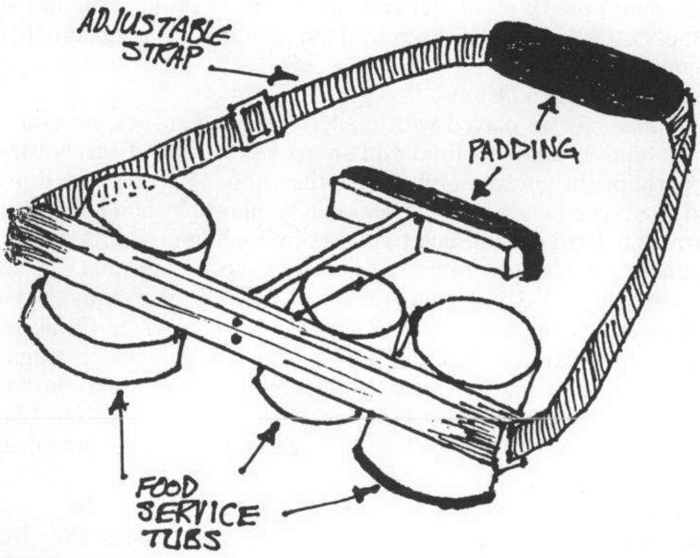


FIGURE 1. Kitchen drums on standing frame (not to scale)



FIlGURE 2. Kitchen drums on portable frame (not to scale).

are attached to a 2x4 crossbar, a short piece of 1x2 may be nailed perpendicular to the crossbar, and a 1' piece of 2x4 nailed perpendicular to the end of that 1x2. The 2x4 piece is then covered with foam rubber or other padding and a strap is attached to each end of the crossbar, to go around behind the neck. I recommend that such a strap be padded around the neck, and if possible, adjustable.

If the drums are then mounted conveniently on the crossbar, the set may then be worn with the padded piece of 2x4 against the chest to hold the drums out and with the strap, as has been mentioned, around the back of the neck. As Kitchen Drums are much lighter than most other drums, a small set may be devised to be worn as described above. A full set, for instance the seven drums mentioned earlier, is as a rule too heavy for such mounting.I have not painted any of my Kitchen Drums, as I expected this to dull their sound. However, Phil "Felipe" Pasmanick actually recommends painting his plastic water bottle conga drums (inside) in a reprinted item in the April 1992 issue of EMI, so you can be the judge of this. However, Kitchen Drums can be painted inside. Painting the outside of the drum would of course result in uneven wear of paint and possibly colored hands. But clear or translucent tubs may be painted on the inside to change their color, or to mask the fact that they are tubs.

While Kitchen Drums may never replace the trap set or the timpani, as inexpensive percussion they are hard to beat.

Circuit-Bending and Living Instruments

THE ODOR BOX

BY QUBAIS REED GHAZALA

I lived in two worlds. In one world I was a prisoner. My freedom was levied by my inmate's misdeeds. I was proclaimed a criminal, a traitor to my country, and became a continual target for the frustrations of a future-bent society with its foot on the brakes. But in the other world... in the other world I was an explorer at the threshold of a forbidden new land where great mysteries swirled in the sunrise and imagination was shot headlong towards what might be. The Odor Box is a shard, a fragment, an ancient relic it seems, thrown out into time by the special detonation that results when worlds collide.

If the photographs of the Odor Box give the impression that the device was built by a thirteen or fourteen-year-old a quarter of a century ago, then I guess they've done their job! It's very rough, and very dated...

Circuit-Bending and Living Instruments, *by Q.R. Ghazala*

THE ODOR BOX

(continued from previous page)

My concerns these days extend into various kinds of construction and finishing aesthetics, but back then I just wanted to get the Odor Box working and set up in a way that was playable. Its construction taught me the principles of what I now call Circuit-Bending* and it served as a launching pad for the nearly 50 more devices to follow, many of which I hope to cover in EMI.

In addition to being the first serious circuit-bent instrument it was also the first "living instrument"* I made, which as I detailed in the last article is basically an audio circuit whose rewiring has caused normal electronic and thermal thresholds to be exceeded resulting in electronics that age and shift a little bit each time the circuit is used. In other words, the voice changes as it grows older like with all living, speaking things. So to begin my instrument discussions in EMI, and for those readers that are interested in the history of an obscure little analog sound generator and the reactions it provoked in a time when synthesizers were relatively uncommon and portable electronic non-keyboard *sonde gratis sonde* instruments were just about unheard of, here is the story.

Sadly, I notice that 60s-bashing has become a sport for both young and old, apparently to remain an enduring pastime for constipated historians throughout eternity. I'm afraid those persons bumming-out on the 60s may feel a bit stressed by the history of the Odor Box since it simply can't be told without reflecting upon this era. If you were out and about in these times, fine. You have first-hand experience behind your opinions, whatever they might be. The following few paragraphs, and a couple more later on, are meant to set the stage for those who weren't there. This may be helpful, as I think you'll see.

As for myself, becoming a teenager in the mid-60's was pretty exciting, and my recollections are very different from those of the current mud-slingers. From where I sat, for a brief moment in history, and in response to the increasing transparency of the "American Dream", alternative philosophies became the guiding light of a dramatically new counter-culture. A stunning diversity of worldly ideas began to take the place of interests in varsity wrestling and the prom (the very fabric of the country was threatened, in other words). Political student activism was at an all-time high. Myself and lots of my friends were jailed for simply voicing realizations that are now the slogans of presidential candidates. But while it lasted, before it was hijacked by the government, exploited by the merchandisers, and diluted by popular culture, something very positive had begun. Since then I've often wondered how difficult it would be for a government or society to try to create a passionate wave of intellectual vitality at its civic core, and considered what a tragedy it was to waste the potential while we had it. Just imagine for a moment everything that could be done with such a resource. Perhaps the bitter critics of the 60s choose to focus only upon what the mainstream media fed the public during those turbulent days, the inevitable downside of the period, the contrived propaganda. Or perhaps they really never saw what was there, so briefly at the beginning, when the great search began for a higher common ground. Maybe they simply weren't there.

However, as I said, I became a teenager in the mid-60s, and I was there. It was during this explosive era that I began bending circuits, and many aspects of my early experimental instruments were directly influenced by those times. My early instruments are a part of those times. Let me explain...

The tangling together of art and science, as I last wrote, has a wild history of consequences, and the counter-culture of the 60s became permeated with the melding of technologies diverted toward the arts. The painter's palette for the first time contained fluorescent pigments which prompted millions of "black lights" to escape the carnivals, magic shows, and store fronts, finding refuge in basements and bedrooms all across the country. As many will recall, psychedelic lighting devices of innumerable kinds began to appear, and artists began to create works that would glow, change color, or seemingly move when lit by these machines. Abstract, pre-hologram 3-D or motion art plaques, dependent upon an assortment of small surface lenses, were hung from walls and ceilings. Sculptures and light-shows based upon liquids became commonplace. It was impossible to drive down a dark street at night without seeing glowing windows lit from within by various shifting hues, and you knew that inside incense swirled, music played, and perhaps people were swept up in a metabolic perception-altering experience, considered by many cultures throughout history to itself be a highly-respected mixture of science and art, something inspiring, even holy. Radically new materials and concepts of all types were injected full-force into the 60s society, and although the general public accepted a portion of it, most was destined to become a brilliant facet of the counter-culture environment. But the most stunning aspect of this abrupt burst of psychedelia and conceptualism is that it was thrust upon a rather drab and naive culture, a culture just beginning on a broad scale to stumble over, and therefore notice, it's own hypocrisies.

To understand the problems an experimental instrument like the Odor Box faced within society during those times, it must be realized that the presumed association in the common mind between "weird music" and "weirdos" was further compounded by the fact that I was an obvious member of the counter culture, and therefore *automatically* a communist, homosexual, and drug addict all at the same time. (Yeah, it was great.) I was perceived as a threat, I built the Odor Box, therefore **IT** was a threat ... and it was a threat.

It may have been '66 or '67, I'm not really sure. I had given up my search for whatever I was looking for in my desk, and I shoved the last drawer closed. The air was suddenly filled with cascading abstract sounds! I couldn't believe it! I looked around, but saw nothing to give me a clue. Could it be the drawer? But I had looked there, hadn't I?

In some rather consuming ways, my life had just changed. The Odor Box was born, destined to teach me concepts of

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* **Circuit-bending** refers to the process of creative short-circuiting by which standard audio electronics are radically modified to produce unique experimental instruments. A further description of these techniques can be read in EMI Volume VIII #1, Sept. 1992.

***Living instrument** is a term I use to describe the circuit-bent device whose rewiring has caused a normal electronic and thermal thresholds to be exceeded resulting in electronics that age and shift a little bit each time the circuit is used. In other words, the voice changes as it grows older, as with all living, speaking things. Again, for a complete description of living instruments, refer to EMI Volume VIII #1, Sept. 1992.

exploring art and science that I've returned to ever since.

Not knowing what to expect, I slowly opened the drawer ... and the sounds stopped. I saw nothing unusual. When I began to poke through the tangled clutter there came another sound, again electronic and bizarre. Then I saw it. A palm-sized transistor amplifier, left turned on with its back panel off and circuitry exposed, was shorting-out amidst the decaying trinkets and salvaged parts. I was amazed. When I also realized I could probably control and elaborate upon these short-circuits. I knew I had stumbled onto something fascinating. I couldn't wait ... I began experimenting immediately.

Over the following few years, three different Odor Boxes would be constructed from that original circuit board, with a fourth instrument to follow, built using the circuitry of an identical amplifier. Many years after that, one of my teachers from art school encouraged me to build another, the last of the series, which I traded for one of his laser-like "Starbox" light sculptures. Each of the five Odor Boxes produced different sounds, all based upon the general behavior of voltage-controlled oscillators and filters (VCOs, VCFs) as well as white noise and tone-burst generators. The reason I say "general behavior" is because these effects as achieved through circuit-bending derive from different electronic realities than those usually employed to produce such sounds and controlling factors. This helps to give the circuit-bent instrument its characteristic voice.

The Odor Box belongs to a class of mid-60s experimental instruments that focused upon the primal oscillatory nature of electronics. This quality was brought out through cyclic pulsing and pitch or filter sweeps of purely electronic textures like those heard in art-rock groups of that era such as The United States of America and Silver Apples.

A device known as the Durrett Electronic Music Synthesizer, as well as the Durrett Ring Modulator, built by Richard Durrett, is heard on the USA album entitled **The United States of America** (Columbia, CS 9614, copyright 1968). The "population" of the USA was Joseph (Joe) Byrd, Dorothy Moskowitz, Gordon Marron, Rand Forbes, and Craig Woodson, who together are responsible for a truly psychedelic excursion into pure 60s experimental art-rock. The work is sharply outlined by electric drums, electronic bass, and electronic violin, surrealistically colored-in with electronic harpsichord, calliope, organ, piano, and the Durrett synthesizer/modulator. Dorothy's clear, ringing voice weaves through the stories of this world, tying it all together into a truly singular music as sweet as it is sinister. If you see this slab of vinyl at your used record shop, grab it!

Silver Apples of the same general time period placed their experimental instrument right up-front ... in fact, it was half of the group. Danny Taylor, playing an 18-piece drum set, combined rhythmic structures with those set-up by Simeon, playing a device known as The Simeon. On the **Silver Apples** album (Kapp, KS-3562), the Simeon consisted of "nine audio oscillators and eighty-six manual controls". The lead and rhythm oscillators were played with the hands, elbows, and knees, while the bass oscillators were played with the feet. Not long after building the Odor Box I remember seeing Silver Apples at a controversial local club known as The Black Dome. Just as with the Odor Box, people were fascinated by the unusual electronics and pure tones of the Simeon. I remember the performance being very intense, very hypnotic, and very inspiring.

The Durrett Synthesizer, the Simeon, the Theremin, and the Odor Box all shared one important design aesthetic. Unlike the gigantic RCA Electronic Sound Synthesizer of Columbia-Princeton fame, the reason behind the construction was not an attempt to build a machine capable of synthesizing a certain sound (or any imaginable sound as was the intent of the RCA Synth), but rather to open to the performer new musical possibilities within the first building block of all electronic synthesis – the basic oscillator. In these simpler devices the pure pitch of the oscillator is monumentalized and set-forth to be manipulated as though it were the single string of the tromba marina or Indian ravanastron, the head of the pedal-controlled tympanum, or the blade of the musical saw ... sufficient by means of its own basic nature.

One significant difference between the Odor Box and these other electronic devices, however, is that the player of the Odor Box can actually become part of the audio circuit, conducting electricity through flesh and blood so that all areas of the body, or a partner's body, can be touched and manipulated much like the standard synthesizer controls. Fingers, noses, tongues (does the imagination wander?) are now modulators for pitch, volume, etc.

I should probably explain the name before I get further into the electronics, so let me again step back 20 or 30 years ....

The Odor Box was named in the spirit of the stream-of-consciousness or word-association literary styles as dramatized in the early Happenings. The initial Happening was presented at the Reuben Gallery in New York during October, 1959. This first Happening took the form of a theater presentation by Allan Kaprow entitled "18 Happenings in 6 Parts". Though Kaprow hadn't intended the word from his title to establish the identity of a genre (he actually felt the coining of the term was unfortunate), the name quickly caught on, and the art-form of the Happening inspired productions by many artists thereafter.

It's interesting to note that these germinal American theater art pieces in many ways reflected the stylistic tendencies of experimental music. Prior to the first performance at the Reuben Gallery, Kaprow had just finished three years of study with John Cage who encouraged expanding the limits of visual art by the same theories he applied to music. In fact, while studying with Cage, Kaprow composed a series of short pieces involving movement and images. These works were clearly reflected in "18 Happenings in 6 Parts," and Cage's influence can also be seen in later Happenings by Claus Oldenburg, Robert Whitman, Jim Dine, Red Grooms, and many others.

Aspects of Kurt Schwitter's collage or "Merz" realizations, as well as Futurist-Dada concepts and the German Bauhaus performances of the 20s, also contributed to the qualities of dance, gesture, scripting, and Environmental Theater that characterized the first Happenings. But Cage's modern influences of indeterminacy and "bruitisme" (or "Noise Music" as originated by the great Italian Futurist, Russolo, who went so far as to construct experimental musical instruments known as Intonarumori, or Noise Organs, to realize some of his works) clearly shaped the Happenings, having much to do with the visual, sonic, and verbal nature of these theater art presentations.

A wider audience became exposed to these abstract expressionist aesthetics as the early 60s Happenings began to merge and blur with the later counter-culture Be-Ins. In the Dadaist tradition these "instant Happenings" were used as the "found environment" for troupes of roaming street-theater performers. As the history books recall, crowds of people gathered in the streets, parks, and campuses as cultural, religious, racial, and socio-economic barriers fell. The solidarity was very positive, and these gatherings were a catalyst for the changing times. The popularization of terms and verbal styles from all these various influences exploded the street slang overnight, fueling a growth of dictionaries and glossaries in a way that hasn't been repeated since. Stream-of-consciousness and

word-association language styles flourished, not only in performance art and song lyrics, but also becoming standard communication in many circles. From silly to sardonic, new wordings and syntax were everywhere. And so ...

As I sat with the little transistor amplifier in front of me on my desktop, short-circuiting all kinds of bizarre sounds out of it with a bent paper-clip spread across its electronics, fate would have it that a bewildered friend of mine listening in the room was having difficulty controlling his eyebrows. When words finally came, and with great theatrical intent, he robustly announced "Them's sure fine odors!" The Odor Box was named, and the name stuck. If you happen to live in Eugene, Oregon, you're probably familiar with Saturday Market and "The Rainbow Guy" from "Out to Lunch". I can *guarantee you* an interesting conversation should you ask him for more details on his inspired title.

Not everything can be put into words. It's difficult to explain a surrealistic name such as the "Odor Box", and I've probably failed to bring across the enthusiastic acceptance that such a frivolous title met with back then. But it was gladly accepted, unquestioned, and the "anything is possible" attitudes of the times *did* play a positive role in the multi-arena experimentations of the day. As a teenage kid with a head full of experimental music and a handful of broken electronics, I can tell you that *my* explorations were definitely inspired by the times, and that's why I've tried to convey a bit of these ingredients here and there.

The first manifestation of the Odor Box, as I stated before, was based upon the body-contact system (see photo below). I was about to solder a switch between two circuit-bending leads that I had just soldered to the circuit board when I discovered that holding the free end of each of these wires in opposite hands made the circuit respond with a low electronic growl. *Very strange*. And when I pressed the stripped ends of the wires more firmly between my fingers the pitch of the growl began to rise, now mixed with undulating ring-modulator overtones! I thought it was great! I was now a bio-potentiometer, a variable human resistor. My body was conducting electricity ...I had become PART OF THE CIRCUIT.

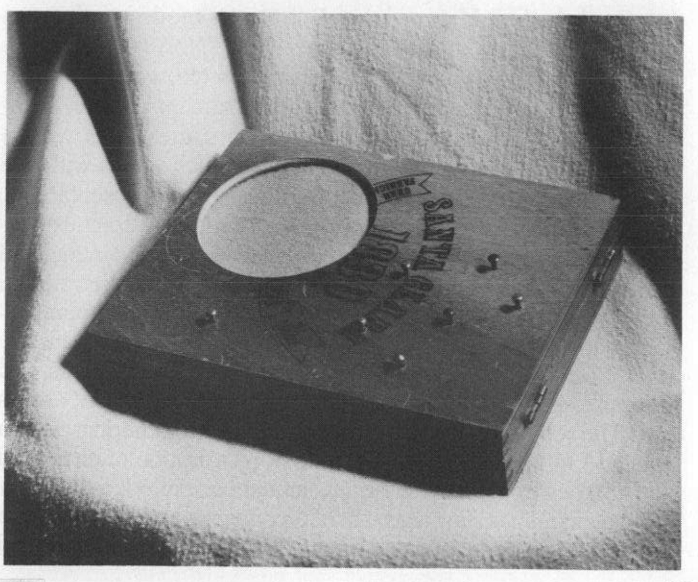
I was part of an electronic loop (I've been worse), and I found that in one hand I held sort of an output wire, and in the other, sort of an input wire. When I held onto the output wire and began to touch various parts of the circuit with my free hand I discovered other good audio points on the board that my body could conduct electricity to, all with different effects. Anyone familiar with early synths will recognize this set-up as the patch-cord system, where the VCOs, VCFs, VCAs and all the other synthesis modules had to be patched together with conductive leads (or patch cords) to configure a working circuit. With the Odor Box electronics (which now included me) it was as though I myself had become the VCA, capable of directing variable current to assorted abnormal conjunctions of VCOs, VCFs, white noise and tone-burst generators, depending on where and how hard I touched. The next step was to bring these body-contact areas, which were thin traces on the printed circuit board or metal housings of electrolytic capacitors at a couple points, out into the open for easier access.

After soldering a wire to each of seven input points on the circuit board, it now having been removed from its case, I then fastened the octopus-like electronics inside a small box so that the thumb-wheel volume control on the board would protrude through a rectangular hole cut in the new housing. Eight brass nails were then driven through the lid of the box. One served as the output body contact, and was placed away from the group of the other seven input contacts. A round hole was also cut into the lid to accommodate the amp's small speaker. The output wire was then soldered to its nail (sticking through to the inside of the box lid), as were the input wires to their body-contact nails.

With this arrangement of controls I was able to comfortably hold the device so that my left forefinger rested upon the "volume" control (standard controls take on uncategorizable new functions with circuit-bending) while my thumb of the same hand covered the output body-contact (nail head). With the fingers of the other hand I could touch the input contacts singly or in COMBINATION. My body was now a SYSTEM of patch cords, but not only that, I had also become a living MIXER able to blend effects into new effects through varying finger pressure as well as changing inputs.

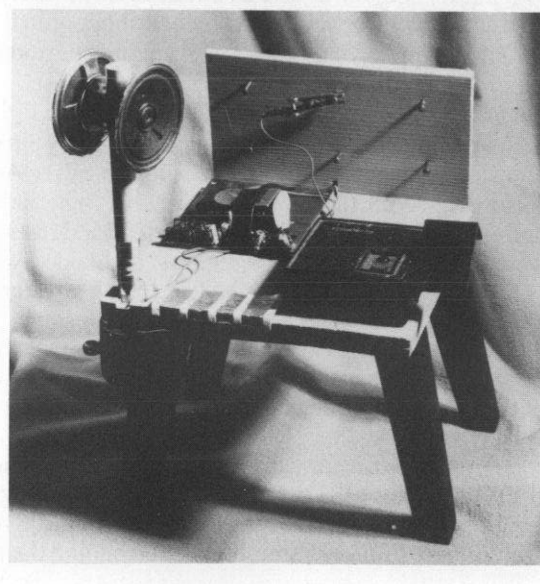
This first Odor Box was a very squeaky device. It warbled and chirped, meowed, barked, and whistled. It ticked like a time-bomb and squawked like a parrot. And with careful touch, it also sang like a Theremin. But of course, as it is with most circuit-bent instruments, the Odor Box's widest vocabulary was one of streaming abstractions.

The device was a real oddity back in late '67. At this stage it was more a curiosity than a musical instrument. Its descendants would be built to elaborate upon more versatile aspects of electronic instrumentation, but I've got to admit that my friends and I had a lot of fun taking the little contraption into



LEFT: First Generation Odor Box, 1967, reconstruction.

RIGHT: Second Generation Odor Box, 1968 reconstruction.



restaurants so that we could gaze around the ceiling while making it chirp under the table. People just didn't carry miniature, electronic, bird-call synthesizers around with them, and we thought the confusion was pretty hilarious as everyone searched the light fixtures for invisible sparrows.

Although this initial Odor Box was fascinating to me, I knew that inside it a more elaborate instrument slept. The next design wouldn't be as complicated as the third version that would eventually follow, but the second-generation Odor Box was probably the most bizarre, and it taught me my first big lesson in crossing sound-art with the wrong audience. Neither the device nor I would escape the encounter unharmed.

I dismantled the original Odor Box in favor of this new configuration (see photo, previous page), :retaining only the best three body-contacts, but adding a 6-channel patch-bay (for direct wiring using the previous body-contact points) and a spinning miniature dual-speaker system. Yeah, it looked doubtful.

As you can see in the photo, the backboard of the second Odor Box was again pierced by brass nails like the lid of the first. As before, these nails were connected to the input contact points, but this time the output contact was extended by means of a wire terminated by an alligator-clip. When clipped to an input channel (nail shaft), one of the same electrical paths that previously flowed through my body would be created, but since the wire conducted electricity much better than I did, it caused the circuit to produce much stronger tones with a wider array of effects. This advancement was a further step toward standard patching.

The three body-contacts that I chose to retain for bio-modulation were now extended to foil pads at the front edge of the instrument. The greater surface-area of these contacts provided a more sensitive interface with the flesh, creating increased range in this area too. These pads could also be used in conjunction with the various hard-wired inputs implemented by the alligator-clip patch bay. All kinds of wild modulations could now be produced.

Two speakers were then attached to a short section of dowel rod, their wires running down its length to two aluminum pie pan bands which encircled the bottom of the rod and provided electrical contact to the speakers as they spun. This assembly was connected to a motor which was wired to a slot-car speed control so that I could spin the speakers at a variable rate. The amp's original speaker was replaced by this system, its two wires running to bent pins tensioned against the aluminum contact bands at the bottom of the new speaker rod.

This second-generation Odor Box was a really eccentric device, and it amazed a lot of people ... but not everyone shared the same enthusiasm. Socially, for teenagers like myself in early 68, it was a time of "hippies,", "greasers"*, and "straights." Actually, it wasn't long before we all ended up at the same parties and found we could share a laugh, but at first I quickly learned that I had reason to worry if I so much as tried to share a sidewalk with either of the last two groups, and if it were the greasers it meant a fight, simple as that. The hippies thought the Odor Box was great, the straights were genuinely curious, but the greasers responded to it as though I were wielding a rusty switchblade.

Most of my friends were musicians. We drifted in and out of various bands, and the Odor Box found its place in a couple of these groups. I would leave the drums, my main instrument at this time, and as the bass and guitar shifted into free-form improvs I would set the speakers on the Odor Box spinning. Extended jams in this style, with the right audience, could be pretty wonderful. But on the other hand, the mistake of playing one night at a Christian church in a local neighborhood that for the sake of clarity I'm going to call "Greaserville", was something altogether different.

Maybe warming-up the crowd with "Alice's Restaurant" was a mistake. Out of an audience of 50 or 60 people we could count only a handful of friends. The rest wanted us to play "Blue Suede Shoes" which, as you have guessed, was not part of our repertoire. The crowd was riled-up before we even went into the Odor Box song.

The device was sitting on a small table in the center of the stage. Since it had no "direct" output it was necessary to close-mike the tiny speakers. This arrangement looked pretty odd, people had definitely noticed it, and when I left the drums to approach it as the guitar and bass entered the improv section the crowd gathered closer.

At first there was an abrupt stillness, a startled silence shot through the audience as the Odor Box produced it's opening wail. Then some jostling ensued, people began to shove each other to see what was going on, how I was producing the noises. The mood quickly changed. A few threats were shouted and some rather mean- looking characters began to gather at the sides of the stage. We kept playing. There occurred then a sort of stand-off. I realized I was able to control the degree of rage in the crowd by how I played the instrument. While politicians and propagandists thrive on such power, I found little comfort in being able to sway, perhaps, the moment or method of what appeared to be my certain doom. But none the less, it was intriguing to witness the effect of this meek experimental instrument upon that gathering of people.

Powerful aspects of conceptual art were at play in these circumstances. As I performed before the hostile crowd I realized that it wasn't as much the sounds as it was the artistic concept behind the sounds that infuriated this audience. With the slot-car motor turned off, creating abstract pulsings by means of the alligator-clip patch-bay produced an agitated tolerance in the crowd. If I drastically modified the sounds by touching the body- contacts to produce effects much more bizarre, the agitation rose only a little. It was the spinning speakers they couldn't stand, and these hardly changed the sound at all. They enraged the crowd. When I turned them on, the wave of antagonism was clearly visible, their effect was intolerable. It was like poking a stick at an angry bear. I might as well have switched on a recording in everyone's brain repeating "Elvis is dead, Elvis is dead, Elvis is dead ..."

And in some rather significant ways, Elvis *was* dead, killed by the changing trends of popular music which clearly swung more towards the electronic arena of the Odor Box every day. Yeah, the Odor Box was a threat. Not by means of its language, but rather by what it said. It spoke of the future.

A broom flew past the Odor Box and hit our keyboardist. It was followed by several hymnals and other articles of worship hurled from the crowd. We noticed that groups of our disgruntled fans were gathering at the exits ... but they had no intention of leaving. We finished the Odor Box jam and I protectively placed the instrument on the floor behind me as I returned to the drums. The exits remained blocked during the next song, and we knew trouble was afoot. Then one of our few friends from the audience overheard what was happening ... the human barricades were in place to stop the Odor Box. The plan was to smash it to pieces.

Need I say that we were a little concerned? We were outnumbered ten to one, and sending a person to the hospital was a badge of honor for some of the guys blocking the

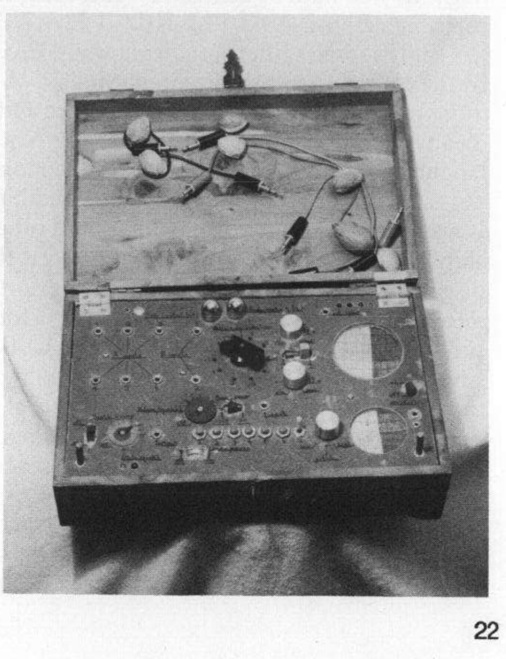
[Editor's note: In the time and social milieu the author is describing, the slang term "greaser" remained free of racial connotations it has since acquired.]

doorways. We finished the set and our friends came on stage to help us break down the equipment. My memories of what happened next are a bit sketchy. I know my friend and I chose our moment, formed a protective wedge around the Odor Box and charged the nearest doorway. Fists flew as we dove through the crowd, forcing our way outside amidst the scuffle. Although not undamaged, the Odor Box did make it to the waiting van and off into the night with shouts for its destruction dying in the distance. We decided not to play there again.

These tensions were destined to fade away. It wasn't long till a bunch of us piled into an old step-van and headed west for California. Our group included some pretty rowdy characters, including a major former nemesis of mine. We slept at roadsides and parks, stayed at the Oregon Vortex concert site where more than 30,000 people would gather, checked out Haight-Ashbury, and lived out of our truck on the streets of Laguna Beach for a while. Thrown together under these circumstances the social barriers were immediately reduced, and we found we could not only get along with each other but have a good bit of fun as well. As misrepresented as it usually was, we'll never know whether the true personality of the 60s counter-culture would have created the initial hostilities or not, but clearly the essence of this movement did, over time, dissolve many hostilities. It was this trend that would eventually defuse the Odor Box.

At the church in Greaserville, the Odor Box had become a triggering device. It triggered, rather than created, the hostilities. The implications that this relationship suggests can be applied not only to experimental instruments, but indeed to the entire realm of experimental art. Impressionism, one of the greatest schools of art, owes its very title to a small-minded critic's attempt to deride Claude Monet's famous early painting, "Impression: Sunrise.". The obsession in society to cling to the old while denouncing the new is at the heart of its own dissatisfaction. It wasn't Monet's brushstroke that so upset the critic, nor was it my sounds. Instead, it was the uncomfortable demand of evolution that angered so many. Is it any wonder that only in death do many great minds receive their notice? Sure, society gets a chance to conceptually catch-up on things, but there's more to it than that. Whether the vision of a visionary is ever recognized or not, it's always been easier for society to deal with an artist's bones than an artist's brains.

Under the steeple in that House of God, two worlds collided. The Odor Box was damaged enough to need rebuilding, a task which I approached with more determination than ever. I refused to accept the idea that this instrument was either destroyed or unwelcome. But I had learned that frailty was hardly an asset of controversial exhibition art! As a result of this collision the third generation Odor Box was then built, this time inside a strong cedar case. (See photo: Third Generation Odor Box, 1968, working original). This version also received a few good blows from likely candidates, but survived to tell the story.



RIGHT: Third Generation Odor Box, 1968, working original.

The body-contacts on this model were further reduced in number. Two silver domes at the top of the faceplate were now the output and the single input to be bridged with the flesh. These proved to be even more conductive than either the prior nail heads or foil pads. The body-contact loop had become so sensitive that I began to experiment with all kinds of conductive paths.

As mentioned before, I discovered that electrical current could be passed through two or more persons, and with very interesting results. With two people, each person would firmly hold a separate body contact. The filter-swept oscillator tone was at this point above the range of hearing. If one person would then touch the cheek of the other, a swift glissando would sweep the pitch down to an audible, steady note. If a finger was added to the forehead, the pitch would drop further. Different events of body contact created their own distinct sounds. Stroking the arm hair, scratching the head, hugging, kissing, and so forth. As you might imagine, moisture creates a very good path of conductivity which will drop the notes way down to slow stacatto pulses. Frequencies across the entire audible range can be produced in this way, inspiring some rather unique compositional situations.

In place of the alligator-clip patchbay was built a more standard patching system using one-eighth inch mini-jacks wired for single- conductor operation. These are the same circuit-bending paths originally found, except that in this new configuration they can no longer be viewed as "output" and "inputs." Since all patch points lead to active spots on the circuit board, I found that plugging a patch cord between two patch points that previously could have been accessed only one at a time (by means of the clip) would produce new sounds. My possibilities of patching were immediately tripled. The main difference in this third generation version, however, was the addition of a multi-position rotary switch. An assortment of nine exotic resistors and capacitors were soldered to the different poles of this switch so that I could send a signal from any of the patch-bay points through for modification. A couple switchable potentiometers were also placed in-line with this new signal route to further extend the range of effects. This refinement, along with the new patch bay arrangement, turned the Odor Box into a complex and extremely variable experimental instrument.

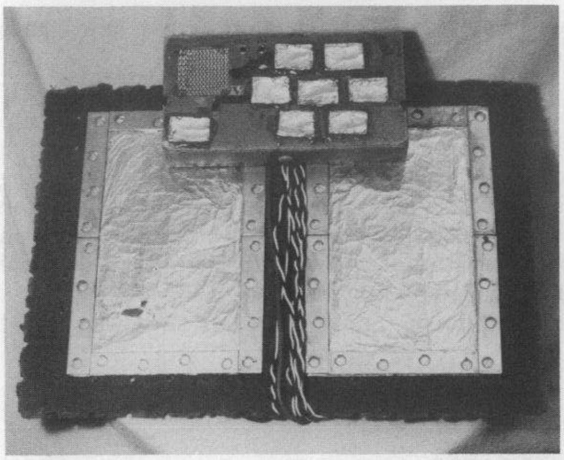
In addition to the Odor Box electronics, along the bottom of the panel I also installed a separate amplifier and tuneable 7-note oscillator. This allowed me to play other instruments through the device mixed with circuit-bent tonalities and drone pitches. As time passed and LED's became available I probed the circuits and found points to attach these so that they would function as status indicators. Learning to read them I further understood the instrument.

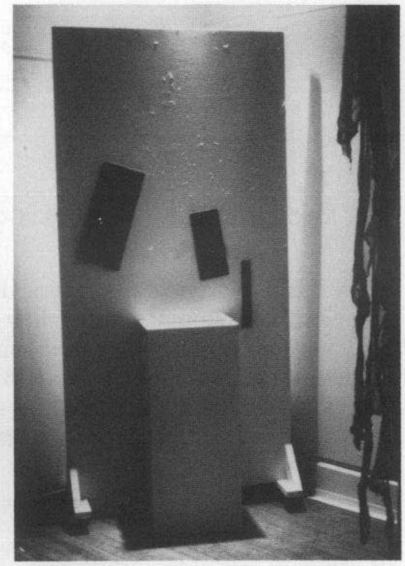
If you're familiar with the classic late-50s and early 60s electronic music of the Columbia University Tape Music Studio and the Columbia-Princeton Electronic Music Center you have a general idea of the third generation Odor Box sonorities. I know it's dangerous to compare a circuit-bent noise box built by a curious teenager to the massive sound synthesis studios of those famous institutions, and the Odor Box clearly doesn't have the controllability or complexity

LEFT: Cat Box, 1968, working original

RIGHT: Flesh as keyboard. Body-contact extension of the Cat Box.

BELOW LEFT: Cat Box exhibit at Arbutus Gallery.





that such equipment wonderfully provides. None the less, on several occasions four-track recordings of the Odor Box have been mistaken for the $25,000 RCA electronic music synthesizer.

The fifth Odor Box mentioned earlier that I traded to an art teacher was essentially the same as the third generation model just discussed, although it did not contain the extra amp or oscillator. The fourth model however, built in '68 like the third, included a noteworthy addition...

The fourth design is called the Cat Box due to its wonderful meows. As can be seen from the photo (Cat Box, 1968, working original) this version returned to the simple design of the very first Odor Box relying entirely upon body-contacts, reviving the multi-channel, flesh-as-circuitry modulation that I had grown to miss. The new addition to this configuration was an output for two remote body-contacts large enough for the entire hand.

During an exhibition of sculpture and performance art organized by Marc Sloan and associates at the Arbutus gallery on the Indiana University campus in Bloomington, the Cat Box was at the heart of a viewer-interactive sound assemblage although it itself could not be seen. Only the large, remote, body-contact plate was presented to the viewer. This plate was placed upon the top of a waist-high pedestal which stood directly in front of a tall partition hiding from view the rest of the electronics. The output from this Odor Box was fed through phasing and flanging circuits and into a spring reverb amp also hidden from view.

From this audio-art construction, as it sat idle, came an ethereal wavering of tones. The gallery was softly filled with wandering notes drifting out from behind the partition. Exhibition-goers were drawn to the voice and would stand before the pedestal contemplating the silvery pads set before them. What is this? What do I do? Should curiosity prevail, one of the pads would be touched and the sound from behind the partition would jump a little bit, the balance of the circuit now being thrown-off by having a human being attached to one of its very sensitive nerves. The viewer-participant's next move, finding themselves neither electrocuted nor evicted, was to place the other hand on the other pad, thereby releasing the genie from the bottle. As if in its idle state the circuit had spread its sound out into space, divided into sections like the matter of an exploding galaxy, the bridging of the body-contacts by the viewer immediately gathered those fragments together into a startling single voice, suddenly upon its creator like a ghoul rushing to the window of a mausoleum to see who dared peek in.

There are Odor Boxes all over the world – strange electronic sound machines made by curious individuals who knew that something might happen ... IF. Unfortunately, + few of these devices ever become known. The space-controlled Theremin, itself an intriguing historic instrument, pales in comparison to the versatility and musicality of Odor Boxes stashed in dark closets and attics across the continents. In 1897, thirty-two years before Leon Theremin performed the First Airphonic Suite, Thaddeus Cahill was performing on the Sound Staves, his curious electro-mechanical device of oscillating membranes. Unlike the Theremin, hundreds if not thousands of other worthy experimental instruments, like the Cahill machine, the Simeon, the Durett device, and the Odor Box, sadly, will have but a moment in the sun.

My further articles in this series will be much more concise. They'll be based upon more recent, more "finished" designs perhaps, and will probably be of greater interest to all. Resisting the temptation to start this series with one of these newer, flashier inventions, I've chosen to elaborate upon the Odor Box simply because, as I stated before, it's the great-grandfather of all the other devices to follow, their circuit-bending techniques being "Odor Box Technology". Though I intend to reach back in a somewhat random order to find instruments for future articles, the Odor Box just seemed to be the right place to start.

I suppose I stand accused ... I'm stuck in the 60s, right? Well, that could be. A lot of me is stuck in the 50s too, and some in the 70s and 80s as well. None the less, the story of the Odor Box is a story of the 60s. When I touch its dials I smell Three Roses incense and hear the laughter and songs now a quarter of a century distant. They're part of the story. Much has changed, but much has not. Clearly, were all stuck in the 90s ... and I find I still live in two worlds.

ACKNOWLEDGMENTS

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A HOLE IS TO HIT

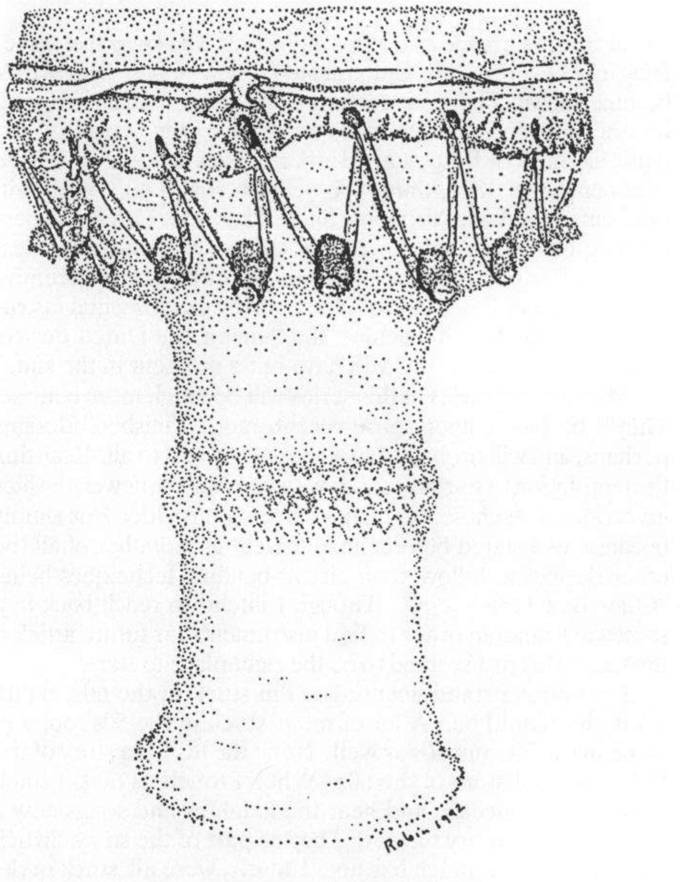
Text & drawings by Robin Goodfellow

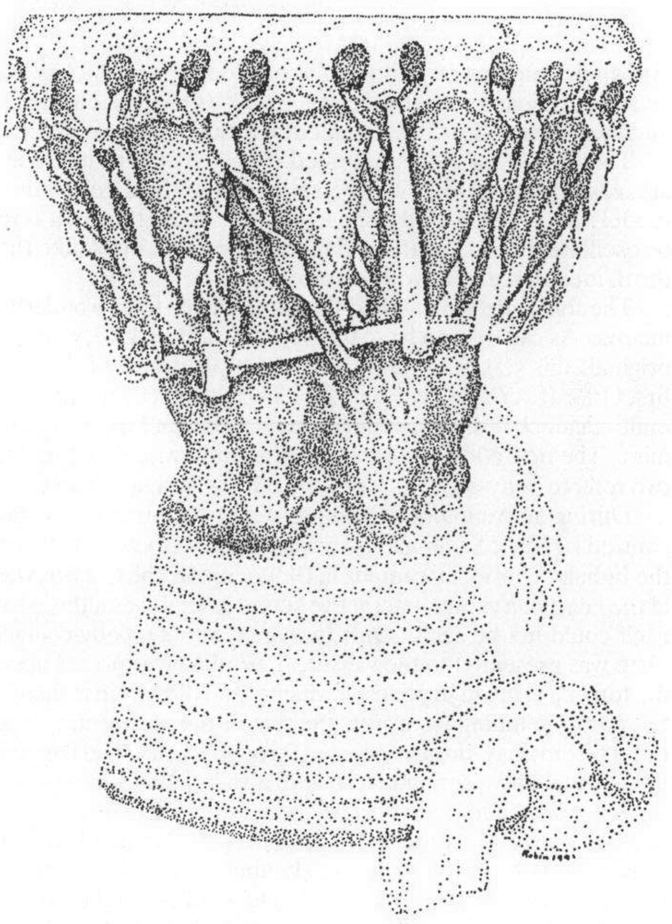
A hole is a magical thing. It is useful for storing things in. Some birds and animals store their families in holes in trees. Holes are good for trapping animals. I suppose that if you made a big enough hole, you could catch an elephant. Then you would be left with a hole that somebody might fall into. Best cover it up. Old pieces of stiff, dried out leather might do. Run across the hole. Make an interesting sound. Dance on the hole.

A HOLE IS TO HIT.

After the resonance of a covered hole was discovered, the mechanisms for covering holes for purposes of creating sounds overflowed in the brains of people and were realized in strange and beautiful forms. The whole thing (no pun intended) was magical, of course. The resulting acoustical implement was called (in English) *DRUM.*

Drums have powers. Some drums are so powerful that





Left above: GOBLET DRUM, DUMBEK

Credit: a gift from the maker, Jill Neff, Berkeley, 1970.

Description: ceramic, goblet shape, single headed; 9" in diameter by 123/4" high.

Remarks: Goblet drums are most common throughout Turkey, South East Asia, Southern Thailand and neighboring countries. One of the reasons for the success of this design is the ease with which it can be transported. An instrument with a waist like this can be held under the arm and played. One could imagine it being played while on horse or camel back and being securely lashed with thongs to packs. Drums resembling this one, with protrusions made of the clay itself for fastening the lacing, have been found in Bohemia as early as 2000 BC.

Right above: GLAZED HOURGLASS DRUM.

Credit: one of a pair, a gift from a previous student, Marianna, and her husband, Arthur Keller, 1991.

Description: ceramic, hourglass shape, N lacing, single headed; 6" in diameter by 81/4" high.

Remarks: This locally made drum (Berkeley, California) is laced with an extra thong, a sort of loose hoop going through the holes in the head, to which are looped the thongs. This probably serves to relieve the strain of the downward pull of the lacing, which are partly twisted and partly flat. The bottom strips of leather are twisted together to form a bottom base, almost hoop-like, for looping the lacing. This is held from slipping upward by the bulge in the shape of the body. The lower portion of the body is open. Handles for a shoulder strap are molded on to the body in back. It has a rich turquoise/blue and lavender glaze. Its tone is as pretty as its visual attributes.

only certain people may ever play them. Sometimes these drums own their own cattle and have people to attend to their every need. What does a drum need, you ask? Well, butter, for one. Truly. Butter, whether from a cow or from coconut is needed, especially in hot, dry climates, for rubbing in to the drum heads to keep them from splitting. Heat, for another thing. Heat keeps rawhide taught and tight, making a drumhead resonant. Wetness loosens a drumhead, causing the tone to go flat.

Drums have accompanied men into battle, exhorting them to kill each other faster and more viciously. Drums gently plead for the benefits of rain for crops. Drums are believed to have powers of healing in some cultures, and in some, when accompanying satirical poems, can punish a person nearly to banishment. With every drum, in every culture, great problems are met and solved.

HOW TO FASTEN THE DRUM HEAD TO THE REST OF THE DRUM BODY.

It is necessary to join the head to the "hole" (the inside of the drum) so that the two can sound together. Solutions to this problem include lacing, tacking, gluing, use of friction and tying on. In the examples below, notice the ingenuity with which people all over the world have solved the problem of how to cover a hole so that it might be hit.

Here are some examples of drum shapes and lacings drawn (literally) from my collection of instruments.

Left:. CHINESE BARREL DRUM

Credit: purchased in Oakland Chinatown 1980s.

Description: wooden, barrel shape, nailed, double headed; 43/4" in diameter at the head by 53/4" high.

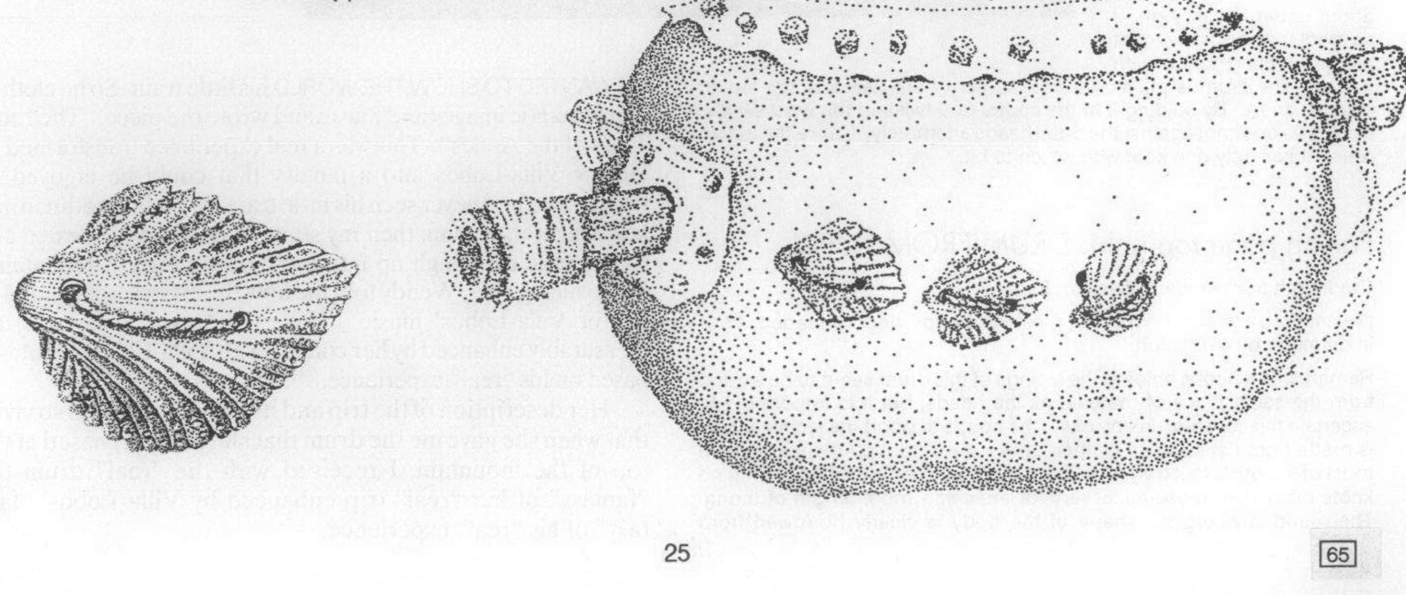
Remarks: Asian drums are most likely to be nailed instead of laced (with some exceptions).

Below: AFRICAN GOURD DRUM

Credit: purchased in Berkeley from Wayne Moskow 1980s.

Description: gourd, kettledrum shape, pegged head, attached rattles, single headed; 51/8" in diameter at the head by 6" high.

Remarks: This drum has pegs, or wooden nails. They are made of some hard wood sharpened on one end and pounded through the head and into the body where they extend from 1/4" to 1" inside. There is a rectangular hole cut into the side of the gourd not visible in this drawing, from which they could be viewed. Attached to the outside of the gourd body are shells, which respond to each beat of the drum head with a higher pitched, sonorous rattle. The shells used are **fragum thurstoni** (Roding, 1798).

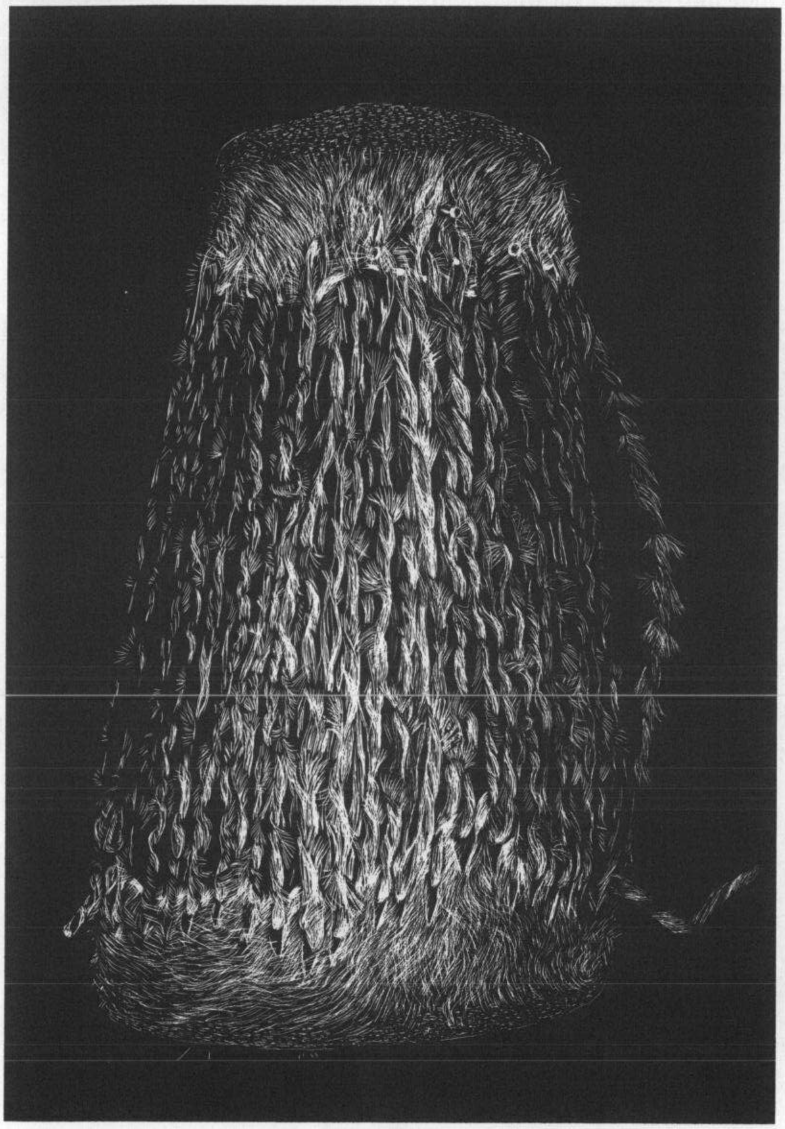


This page: AFRICAN CONICAL DRUM

Credit: purchased in the early 60s, probably from Cost Plus in San Francisco.

Description: wooden, conical, parallel lacing, double headed with internal object; 5/2" in diameter by 101/2" high.

Remarks: The heads and the thongs of this drum still have the hair of the animal attached. This gives the twisted lacings a beautiful pattern. This type of drum is sometimes made of the hides of zebras or other distinctively marked animals and are usually played in pairs. The stiff head of this drum is not particularly resonant, as a thinner head would be. It has two pitches of percussive sounds, one at either end. There is some sort of object inside this drum. This sounds when the drum is rotated so that the object inside strikes the larger or smaller head.



Facing page top left: BRITISH GUIANA CLAPPER DRUM

Credit: purchased at no-longer-existing curio shop, **Scotty's**, in Portland, Oregon, late 1950s.

Description: metal, cylindrical, cords laced to three hoops for each head, clapper, double headed; 3" in diameter by 4" high.

Remarks: This drum from British Guiana is most likely made from a discarded tea tin, or tin can. The heads are held in place with no less than three hoops. The lacing goes under and over the top hoop, and over the next two. The two hoops are made of what looks very much like thin strips of bamboo. These strips are bound to themselves by lacings of cords and friction, probably from drying on the drum. The inner hoop is more completely wound with a red material rather like raffia and free to move about under the lacings. I suspect that this movement has something to do with tuning. The drum is played in the manner of the **damaru**, the Indian clapper drum. By holding it in the center and twisting the wrist swiftly, it plays its one knot against the drumheads alternately. Unlike the Indian drum, it has only one knot with which to hit.

Facing page top right: DRUM FROM NEPAL

Credit: gift from student, Bassem Elias.

Description: wooden, hourglass, X lacings, hoops, double headed; 47/8" in diameter by 41/2" high.

Remarks: The hoops holding the lacings of this drum seem to be wound from the same piece of material as the heads, but it is impossible to ascertain this for sure. In any case, the hoops support the lacing, which is made from flat strips of leather, unlike the cord type thongs used in most of the other laced drums. The lacings loop over the hoops with no knots other than those necessary for attaching more length of thong. The rounded hourglass shape of the body is clearly borrowed from pottery designs. It appears to be turned on a lathe and is painted green. Squeezing the lacings produces a rather wide range of pitch differences, almost as great as that of a large African talking drum. Talking drum messages could be sent on this drum, but not too far, as the sound is not very loud.

Facing page below: MEXICAN FRAME DRUM

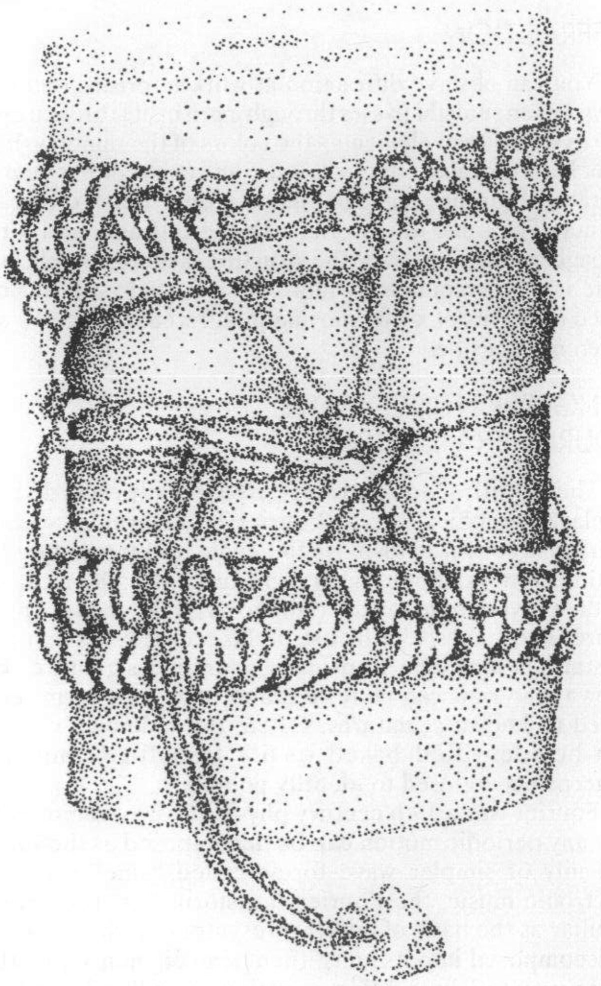
Credit: gift from previous student, Naomi Goodman and her mother, Wendy, 1970s(?).

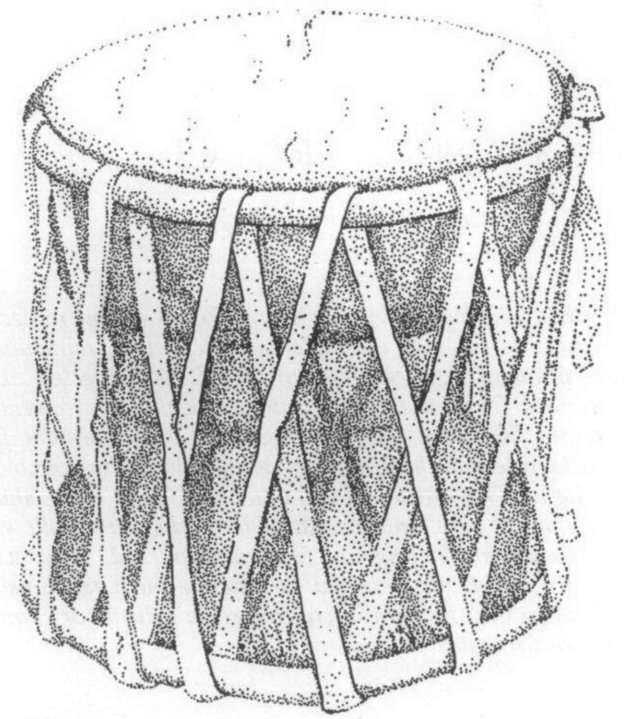
Description: wooden strip, frame drum, mostly N lacing, merges in and out of W, double headed; 9" in diameter by 3" high.

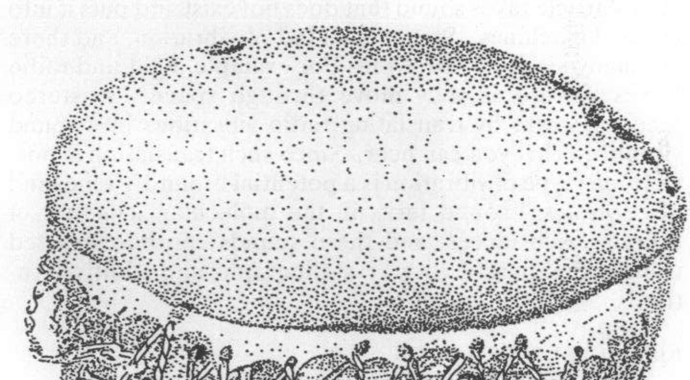
Remarks: The frame body is made from a roughly hewn strip of wood fastened together with a piece of wire pulled tightly through two holes that look as though they have been burnt rather than drilled. The thin, strong skin has holes through which the narrow lacings are pulled. One of the heads is slightly too small for the frame and the holes are stretched up and over the edge onto the head itself. There seems to be no problem, however, and the drum has one of the sweetest tones in my whole collection. The heads of the drum are not completely round, due, I assume, to the lack of pliability of the strip of wood of which the frame is constructed. This seems to cause overtones in parts of the head, creating a variety of pitches located in different part of the heads. The two ends respond differently with both of them having a particularly resonant spot near where the wood frame is joined to itself. Although it does not show in the drawing, most of the lacing is N shaped, merging in and out of W shape. A small stick is pounded into the side of the drum and wound with turquoise colored thread. A separate piece of the lacing material is tied on for a small handle.

HE WANTED TO SHOW THE WORLD his little train. So he clothed it in romantic images and music and wrote the piece, "The Little Train of the Andes". This was a real experience transformed by Hector Villa-Lobos into a fantasy that could be enjoyed by people who had never seen his little train. Wendy Goodman and her daughter, Naomi, then my student, traveled to Mexico and took a little train high up into a different range of mountains. With shining eyes, Wendy told me how the experience reminded her of Villa-Lobos' music. Her "real" experience was immeasurably enhanced by her contact with Villa-Lobos' "fantasy" based on his "real" experience.

Her description of the trip and its associations was so vivid, that when she gave me the drum that she had purchased at the top of the mountain, I received with the "real" drum the "fantasy" of her "real" trip enhanced by Villa-Lobos' "fantasy" of his "real" experience.







It seems to me that the study of the history of instruments (or anything) is similarly enriching. History, once it has happened, becomes "fantasy" to the people who hear about it. It creates images that enrich what they are doing at the moment with instruments in "real" time.

Thus the study of the history of these drums gives me the ability to look at one instrument and see the panorama stretching backward of all of the colorful people and things involved in its evolution. It seems as though I can feel the texture of the animals, the smell of the marketplaces, and see the lavish decorations of the homes these old drums lived in. Kings and shepherds, people close to the earth and people marbled off from this earth in palaces, the drums were in all these places.

I am intrigued by the myriad solutions to the problem of how to make the cover stay on the hole. Will the study of these different, world wide systems help me design new instruments of my own? Will it help me be more tolerant of students' unorthodox use of materials and techniques in building their own instruments? Will it give me the courage to approach people who are very, very different from me in lifestyle, language and expectations and meet them with a spirit of sharing about instruments?

How *did* the design of that little frame drum get to the high mountains of Mexico?

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THE SOUND OF CRYSTALS

by Bill Sethares and Tom Staley

One of the methods physicists use to learn about molecular structures is to study the patterns of reflection, refraction or absorption of different frequencies of light directed at the molecules. The resulting data is not musical in any conventional sense of the word, but for a musician seeking new and fresh models for establishing musical relationships, the possibilities are there. Two articles in this issue of EMI – the Sethares-Staley article here, and the Alexjander article that follows – describe systems for mapping such molecular data into musical patterns. Both are designed to generate pitch relationships, which can then be used in creating scale systems or complex, composite musical timbres.

Imitative sound synthesis takes sound that actually exists and puts it into musical machines. The method described in this article takes sound that does not exist and puts it into musical machines. Sound is a kind of vibration, and there are many kinds of vibrations. For example, light and radio waves vibrate as they move through space. A stereo receiver works by translating radio vibrations into sound vibrations that you can hear. Since such translation is possible, any type of vibration is a potential "sound". One kind of "noiseless" sound lurks in the molecular structure of everyday substances, and these sounds can be extracted using techniques of x-ray crystallography and additive synthesis.

NOISELESS SOUNDS

The simplest example of a noiseless sound is one which is pitched too high or too low for human ears to hear, like a dog whistle. Clearly, it is possible to record or sample a dog whistle, and to then play the sample back at a slower speed, thus lowering the pitch so that it can be heard. Another translation technique, much like a radio receiver, was recently employed by Fiorella Torenzi in her work *Music from the Galaxies*. Rather than beginning with a dog whistle, she starts with digital recordings of the microwave radio emissions of various interstellar objects. These are slowed down until they are transposed into the audible range, and music (or at least sound) is created. Dr. Torenzi calls her work *auditory astronomy.*

There are other, less obvious noiseless sounds in nature. One of the authors works regularly with a technique called x-ray diffraction, which is a way of discovering and understanding the molecular structure of materials. The idea is to shine an x-ray beam (think of it as a flashlight) onto a crystalline structure. The x-rays, which vibrate as they move, pass through the crystal and are bent when they hit the atoms inside. Because of the pattern in which the atoms are arranged, the x-rays bend in a few specific directions. This process is known as diffraction.

DIFFRACTION

You can observe diffraction at work in prisms and rainbows. When sunlight passes through a prism, it is broken apart into its constituent elements - the colors of the rainbow. Each color has a characteristic frequency, and each color is bent (or diffracted) through an angle that is proportional to that frequency. The same idea works with the diffraction of x-rays through crystals, but since the structure is more complicated, there is a correspondingly more complicated pattern, composed of beams of x-rays moving in different directions with different intensities.

"FINGERPRINTING" WITH FOURIER TRANSFORMS

These "diffraction patterns" are typically recorded and displayed graphically as a "Fourier Transform," a spectral chart that concisely displays the angle and intensity information. For example, the transform of the chemical bismuth molybdenum oxide ($Bi_2Mo_3O_{12}$) is shown in the figure. The main scientific use of this technique is that each crystal has a unique transform, a unique signature. Unknown materials can be tested, and their transforms compared to known signatures. Often, the unknown material can be identified based on its transform, much as fingerprints are used to identify people.

Fourier was a 19th century physicist who demonstrated that any periodic motion can be decomposed as the sum of a family of simpler wave forms called "sine" waves. In electronic music, the Fourier transform (or spectrum) is familiar as the basis of additive resynthesis, where a sound is decomposed into its constituent sine elements, and then reconstructed by adding together a collection of appropriate sine waves.

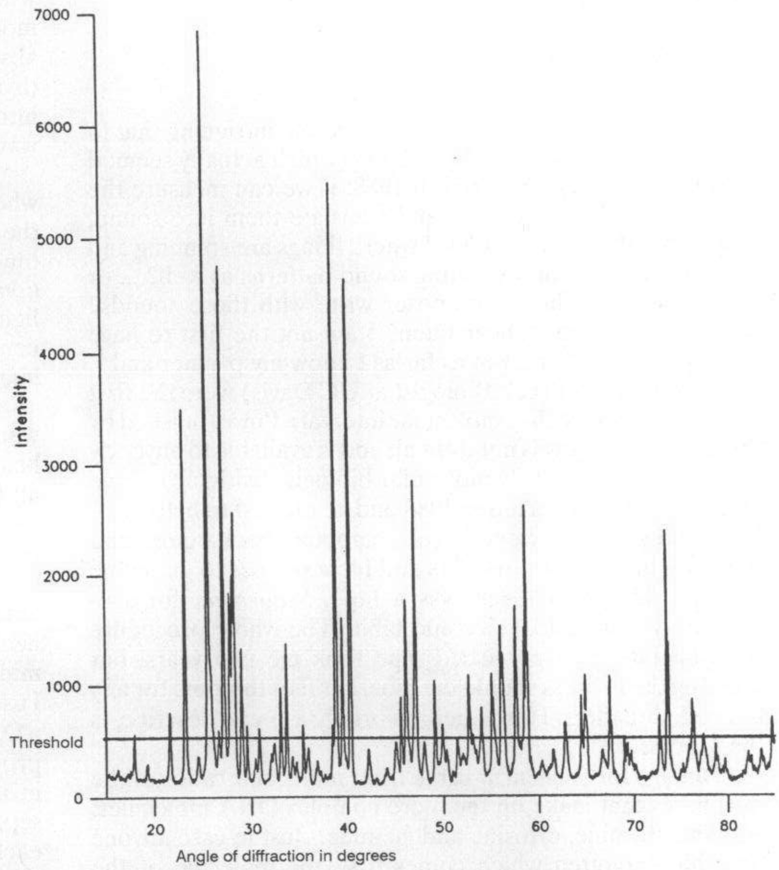
TURNING DIFFRACTION PATTERNS INTO SOUNDS

In materials, any periodic physical structure (which we call a crystal) reflects electromagnetic energy (such as x-rays) in a characteristic way that can be decomposed into a collection of angles. Thus the angle of the diffracted beam in crystallography plays a role similar to sine waves in sound. This provides a natural analogy between the Fourier transform of the crystalline material and the Fourier transform of a sound. The intensity of the energy at each angle can be similarly translated into sound wave amplitudes. This, then provides a basis for the mapping of x-ray diffraction data into sound data, and defines a method of *auditory crystallography*, in which the spectrum of the crystal maps naturally into the spectrum of a sound.

A base frequency, or fundamental, must be chosen in order to realize the sound. This choice is left to the performer by assigning various fundamentals to the various keys of a keyboard, allowing the "crystal tones" to be played in typical synthesizer fashion. In generating the sound data, the fundamental frequency is based on the angle which has maximum intensity. Referring to the figure, the largest spike occurs at

an angle of about 25 degrees, which we call θ_{max}.

X Ray Diffraction Pattern, Sample ST12



Each angle θ_i of the x-ray diffraction pattern maps to a particular frequency fi via the relation

$$f_i = \sin(\theta_{max})/\sin(\theta_i)$$

This formula transforms the x-ray diffraction angles into frequencies of sine waves. In general, angles that are less than θ_{max} are mapped to frequencies higher than the fundamental, while angles that are greater than θ_{max} are mapped to lower frequencies. This feature of the mapping is responsible for much of the uniqueness of crystal sounds, since normal (instrumental) sounds have no tones below the fundamental. Since both $\sin(\theta_i)$ and $\sin(\theta max)$ can take on any value between 0 and 1, f_i can take on arbitrarily large (or small values).

To see how the formula works, grab a calculator that has the "sin" function. For a θ_{max} of 25 degrees, calculate $\sin(\theta_{max}) = \sin(25) = 0.4226$ (if you get -0.1323, change from "radians" to degrees). To find the frequency corresponding to the spectral line at 41 degrees, calculate $\sin(41) = 0.6560$, and then divide $0.4226/0.6560 = 0.6442$. Thus the frequency of this sine wave is 0.6442 times the frequency of the fundamental. For an A note at 440 cycles per second, this would be $440x0.6442 = 283$ cycles per second.

The amplitude of the sine waves corresponds to the intensity of the θ_i, and may be read directly from the graph. Referring to the figure again, the amplitude of the sine wave with frequency corresponding to an angle of 41 degrees is about 2/3 as loud as the amplitude of the fundamental. Designate the amplitude of the ith sine wave as A_i. The complete sound can therefore be generated from the frequencies f_1, f_2, f_3, ... with amplitudes A_1, A_2, A_3, ... via the standard techniques of additive synthesis.

As a practical matter, the number of frequencies must be limited. In our experiments, we have deleted all frequencies with amplitudes below a given threshold. The threshold for $Bi_2Mo_3O_{12}$, for example, is shown in the figure. This typically results in 25-35 distinct frequencies f_i in the final sounds. The crystal sounds were generated on a personal computer, and then sent via MIDI to an Ensoniq EPS sampler. The sounds were then looped, and performance parameters like modulation, aftertouch, and amplitude envelopes were added.

We have recreated the sounds of numerous materials including glucose, tartaric acid, topaz, roscherite, reserpine, a family of Bismuth Oxides, cocaine, and THC. Unfortunately, research has shown that listening to materials does not necessarily have the same effect as consuming them. Numerous other materials are available, and we plan to continue exploring these. There are several sources for x-ray diffraction data, which can be obtained at technical libraries.

HOW DO THEY ACTUALLY SOUND?

The most striking feature of the crystal sounds that we have listened to is their aharmonicity. The spectra tend to be extremely rich in frequencies within an octave of the fundamental since the major peaks of the spectrum often lie in clusters. This is in stark contrast with conventional harmonic timbres that consist of integer multiples of a single base frequency. Crystal timbres do not sound like standard musical instruments. A tempting analogy is with bells, which tend to have quite nonlinear spectra (partials not related by simple integers). When the crystal tones are struck, and the sound is allowed to die away slowly, they do resonate much like a bell.

While some of the sounds we have tried (THC and roscherite, for instance) sound very similar, most are quite distinct. Perhaps the closest comparison is with synthesizer patches with names like "soundtrack," "metal vapor," and "space pad," which give an idea of the subjective flavor of the sounds.

In summary, we have exploited the spectral interpretation of x-ray diffraction data to provide a natural mapping into sound parameters, giving a way to "listen" to various crystal structures and to "play" the sounds of materials. Originally we had hoped that by listening to the sounds produced we could learn to identify the material from which it came, using the ear as an aid in data analysis. Though we have been unsuccessful in completely realizing our goal of auditory crystallography, we do seem to have uncovered an interesting method of sound generation.

DNA TUNINGS

by Susan Alexjander

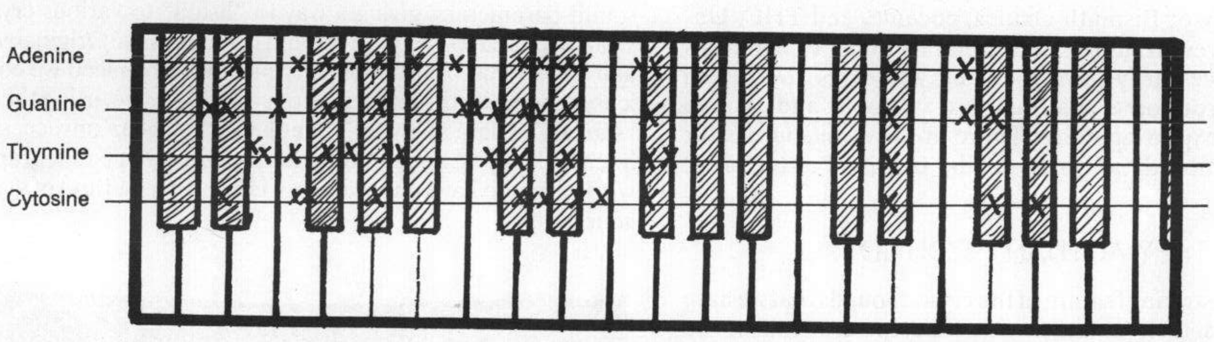
Sometimes one is seized with an idea so intriguing that to follow it up is irresistible. A question (which actually seemed reasonable to me) appeared in 1988: if we can measure the periods of planetary orbits and translate them into sound, what about the molecular level where things are spinning and vibrating ... aren't they creating sound patterns as well? ... or something? Couldn't a composer write with those sounds? How are we going to hear them? I am not the first to have asked these questions, but as far as I know my partner and I, Dr. David Deamer (cell Biologist at UC Davis) were the first ones to sonically realize molecular intervals. I'm astonished by this because it really is not difficult and is available to anybody with access to a friendly molecular biologist (with lab). Dave Deamer and I connected in 1988 and he offered to help me. I had not a shred of scientific (or computer) background and relied on him, other physicists and techno-types to guide me through. The final result was a tape, *Sequencia,* for synthesizer, violin, cello, voice and tabla. The whole procedure from beginning to published tape took me two years, but knowing the process should cut months off of this time for any interested readers. Here, then, as briefly as I can describe, is the process.

Tunings for *Sequencia* came from molecular ratios of the four bases that make up the more complex DNA molecules: adenine, thymine, cytosine and guanine. Just in case anyone here has forgotten which comes first, the molecule or the atom, here's a mini review. Atoms (like carbon, hydrogen etc.) make up molecules. The atoms cluster and bond, and jiggle and vibrate. There are simple and more complex molecules ... each DNA base is a simple molecule made up of four kinds of atoms (carbon, hydrogen, oxygen and nitrogen) – the stuff of all life. The DNA double helix is a more complex molecule in its entirety. I mention this because sometimes there are references to the "resonant frequency" (however they measure it..?) of the DNA molecule, and I am sure the authors refer to this larger structure: my work was with the individual bases, and atoms.

The raw data that forms the basis for molecular music are light absorption spectra for the four bases. By "shooting" molecules of each base with light, scientists can measure which wavelengths are absorbed, or resonated in the molecule. Dr. Deamer was able to measure 18 different absorption wavelengths for adenine; 16 for guanine, 13 for thymine, and 13 for cytosine. To convert the wavelength data into frequencies, you follow the formula $f = c/l$, where l is the wavelength and c is the speed of light.

Now a cautionary word about this ... there is a temptation when working with both the light and sonic spectrum to see the two of them as having a direct relationship; that is, D# is blue, etc. I think we must be very careful. There is a *correlation* from light to sound, but no one can prove that a certain light frequency is a particular pitch other than for the sake of convenience. What we can say, I think, is that a series of light *intervals* can correspond to a series of sonic intervals.

So now, after converting from wavelengths to frequencies, what we have are frequencies so high as to be far beyond the hearing range, which must be octavized down to be heard at all (each halving of the frequency corresponds to a drop of one octave). They were brought down thirty-six times, although thirty-two would have brought the frequencies within the audible range. (Interestingly enough, this is roughly the amount of times planetary orbits have to be sped *up* to be heard – it seems Hermes was right, we are standing in the middle). To hear these pitches which are mainly microtonal I used a Mac SE computer with Editor Librarian software and a DX7 IID Yamaha synthesizer. The procedure is simple: just program in the frequencies and they are sent to the synthesizer in any chosen order. It seemed logical to work with four separate scales or pitch collections (from low to high), one for each base, and then created a keyboard of all 60 pitches together. The highest tones are associated with the lightest atoms in each molecule: hydrogen...they become sort of Es, Fs and F#s on our western scale. Oxygen, the next lightest, are Fs and F#s an octave below. Approximately 15 pitches out of 60 fall directly on our equal temperament scale and the entire spread is about 2 and 1/2 octaves. There are octave and fifth relationships within *each* base...not surprising in terms of "natural" laws but the odds mathematically must be pretty high against that happening randomly. These intervals are within four cents of just, and in some cases within 2 cents. I've also found these close matches with just thirds, fourths and whole tones, or in other words, relationships to the first nine partials (including the flat 7th partial). I'm now in the process of measuring for relationships to the higher partials, just to see



APPROXIMATE PLACEMENT OF PITCHES RELATIVE TO EQUAL TEMPERAMENT

if any patterns emerge.

There were some interesting performance problems with *Sequencia*. Since I wanted acoustic instruments as well as electronic sounds I first found players sympathetic to the cause, then pitches for them as close to their own tuning as possible. The background tape which plays in performance allows for more of a microtonal flood of sound. I don't recommend scoring a live keyboard part for these tunings...the problems result in a gestalt-like nightmare for any accomplished player since the notes you activate on the synthesizer sound nothing like what is written on the page! *Sequencia* features sections for each individual base as well as ensemble or tutti sections when all of them are combined. An interesting sideline here: the pitch which I chose to tune the ensemble "scale" keynote to was C# just because it fell into place as a natural aural "center" or drone tone. Later I learned that this same frequency (136.1Hz) is the Sa (or Do) of Indian tuning that is most often used, and the pitch that most tabla are tuned to.

There are lots of "so whats" here. I agree with Aristotle's pronouncement that the ear should be in charge of sound, not numbers. But the concept of the universe as song (numbers made audible) is just too tempting. It's possible to hear any molecule using this system. Dave Deamer has given me wavelengths for water, caffeine, even LSD ... One final word. In spite of all that the musicologists and acousticians tell us about our preference for low (or simple), prime-numbered ratios such as 2/3 and 3/4 (5ths and 4ths), not ONE person has ever complained about the strangeness of these tunings. In fact, the word most often used is "familiar."

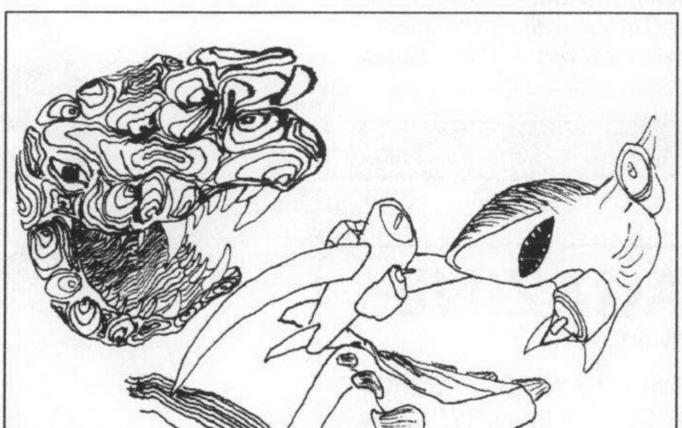
Susan Alexjander teaches classes in "Sound and Consciousness" at John F. Kennedy University in Orinda, California, and does sound track design, composition and radio work in the Bay Area. She also teaches privately. The cassette tape Sequencia *is available from Science and the Arts, PO Box 27555, Oakland, CA 94602.*

MOTORIZED GUITAR OBJECTS

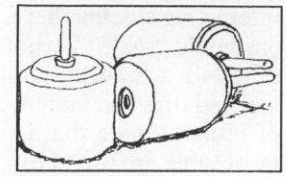
Art and words by Glenn Engstrand
Photography by Dorah Rosen

Electric guitar pickups are designed to respond to movement of metallic objects within their magnetic field. The idea is that the vibration of the metal guitar strings across the field will induce an alternating current in the coils of the pickup, in a pattern of alternation that is analogous to the string's pattern of vibration. The electric signal thus generated is amplified and sent to a loudspeaker. But guitar strings aren't the only things that will induce a current in the coil. Particularly potent, for this purpose, are small electric motors, with their rapidly spinning electromagnetic components, held in proximity to a pickup. One of the striking things about playing a guitar this way is that it looks so very strange — especially if the motor is contained, say, in some battery-driven toy animal that appears to be trying to eat the pickup, and generating the most fearsome noise as it does so. In the article that follows, designer and author Glenn Engstrand introduces this peculiar style of electric guitar virtuosity, and some of the engineering behind it.

There are many who struggle in the day-to-day battle against the tyrannical forces of conformity; improvisers, new music composers, and instrument inventors. They are all experimenters of the highest caliber; stalwart heros in the poetical advancement for the liberation of mind. Yet few are aware of the lone voice of the brave *motorized object guitarist* that soars high in the heavens, piercing deeply into enemy territory. One such pilot, Davey Williams, is a seasoned veteran of many flights – playing free, improvisational music with such greats as LaDonna Smith, Derek Bailey, Henry Kaiser, and Tom Cora. Part of his hallmark is the use of motorized object guitar and, as a consequence of his many years performing, he has developed an exceptionally large vocabulary with this type of experimental musical instrument. But for every pilot in the air there is a team on the ground that is dedicated to keeping him flying. This is the story about those men and the problems they face in the design, construction, and maintenance of those high technology, tactically advanced, professional grade motorized guitar objects.

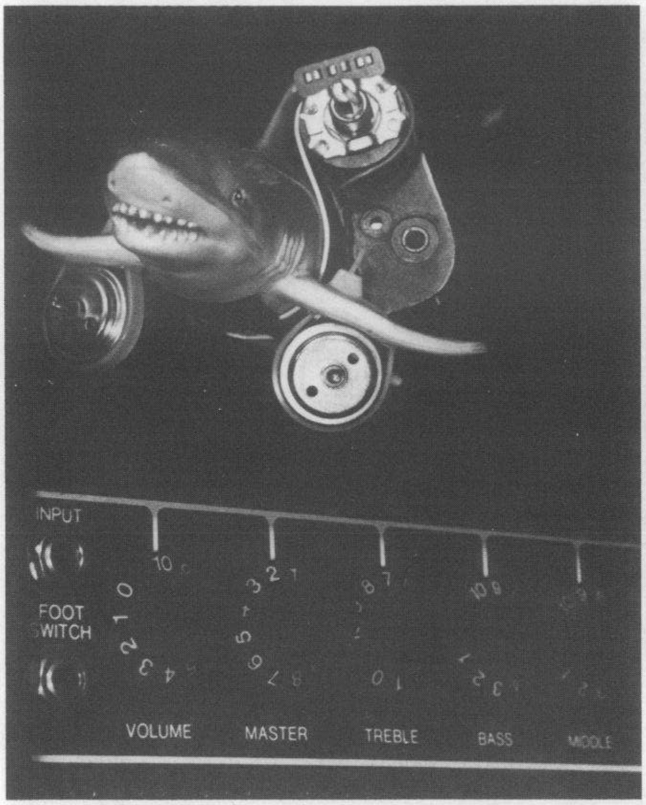


First discovered by Hans Reichel (who played his guitar with an electric shaver), motorized object guitar methods are based sonically and visually on interplays between objects of both archetypal and poetical significance. Utilizing the guitar as their voice, these objects and interplays are intended to set in motion certain essentially intuitive or subconscious mechanisms. The subconscious sees objects as keys, or signatures even, which it may recognize as cues for automatic actions (WILLIAMS85). In order to satisfy this strategic objective, professional grade Motorized Guitar Objects (hereafter referred to as MGO) must comply with the following aesthetic guideline: they must be "unique virtuosities of pure tonal and visual impact which even today break out of musical idiom-corrals" (WILLIAMS82). This exploits the mode of perception, known as objective humor, which is "a synthesis in the Hegelian sense of the imitation of nature in its accidental forms on the one hand and of humor on the other. Humor, as a paradoxical triumph of the pleasure principle over real conditions at a moment when they may be considered to be the most unfavorable, is naturally called on as a defense during the period, heavily loaded with menaces, in which we live" (BRETON37).



MGO must also be theatrical. Remember that, when the object is in use and is the focus of attention (both visually and acoustically, by the audience and the performer) it should look interesting as it is being played. For example, sometimes Davey will use a toy stuffed mouse with a motorized fish (now retired). The mouse has a functional use (it helps to damp the motor) but it also turns the fretboard into a scene from some kind of REM-state Tex Avery cartoon.

But it was my background in engineering that started my career in MGO. I came on board as part of the "crack team" of "industry experts" that developed the landmark **Godzilla** prototype. The team was headed, at that time, by the legendary Roger Haggarty (codename: Dick Foot) who is the saxophonist in the Reverend Fred Lane's Hittite Hot Shots. The construction of this prototype came out of the "readymade" school of MGO housing by taking a plastic toy version of the famous Japanese movie character and, with an incision up the belly, installing the power and control systems of the MGO in her torso. The original idea was to use a diplodocus but we never found one that was up to "specs." I remember that first night when Dick Foot called us in and explained the objective of our mission. "Boys", he said; he always said that. I hate being called a boy. "Boys, we're in a bit of spot here. One of our top pilots, from the sononautical division, is down. He needs our help." That was when I was introduced to the complex and multifaceted world of MGO.



AERIAL SHARK

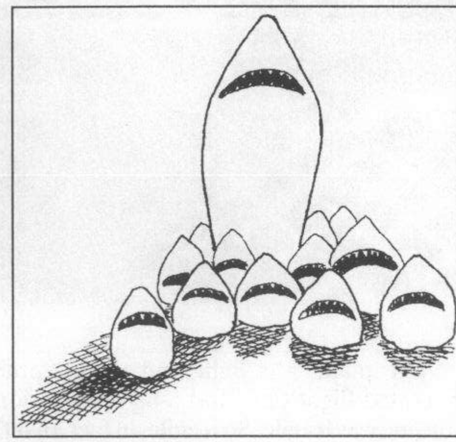
One of the first problems that we encountered was that today's alkaline batteries are geared more for digital applications than the high inductance hobby motors used in MGO. What that means is that alkaline batteries produce less current than regular batteries. They discharge faster, thus limiting the length of time of flight. In order to extend the theater of operations, we learned to use old fashioned (non- alkaline) batteries.

An interesting thing about **Godzilla** was her schematic. She had two motors (she held them like beer steins in her hands) one of which was in parallel with a potentiometer (mounted in the tail). What that did was, when you slowed one motor down the other motor would speed up. Thus **Godzilla** always had a simultaneous rising and falling pitch effect. She could bank on a dime.

Developing **Godzilla** gave me exposure to the first design parameter, *power*. The trade-off for power is essentially this: the more batteries, the longer the flight but the heavier the payload (thus harder for Davey to play). The fewer the batteries the easier it is to play but the shorter the flight.

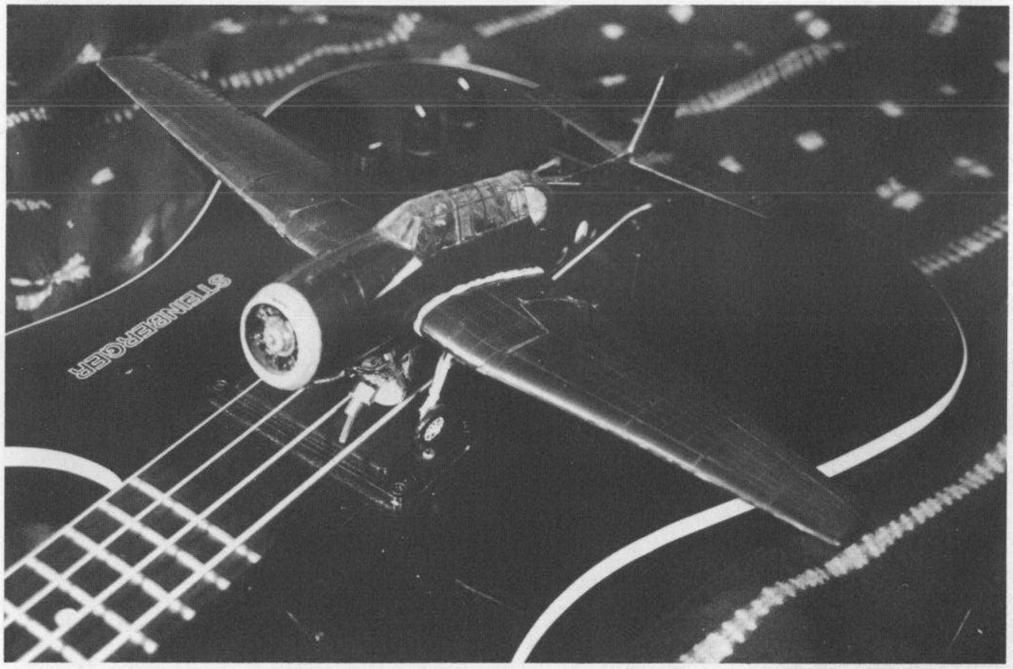
It was my second project that introduced me to the design parameter of *fault tolerance*. Fault tolerance is the number of failures that a system can experience before the system itself fails. To design for fault tolerance, you must first identify the mission-critical subsystems. For MGO, those subsystems are the power system, the engine, and what connects them together. Those subsystems must then be duplicated and a switching network installed to switch from primary to backup in the case of subsystem component failure.

That was when I was included in the **Flying Glove** refit. The **Flying Glove** was originally designed by Davey's brother, Johnny, but was decommissioned because she broke down too easily too often. I redesigned her as an eight-engine bomber with dual coupled power systems and a 4 by 2 hypercube switching network. In normal operating conditions, the power systems could be run in single (normal flight) mode or dual (afterburner) mode, but during a failure one power system is used as the backup to the other. Though she would stay in the air and would not crash, she was unwieldy and, therefore, hard to maneuver.



This unwieldiness gave me an appreciation in the importance of *ergonomic design*. "Ergonomics" refers to the ease of use. For MGO, this means how light the craft is, how easily it fits in the hand, and how easy it is to pick up and put down.

Next, I developed the **TBF Avenger** by taking a hobbyist model of the famous Navy plane and mounting a motor where the engine would be in the model. The motor's shaft stuck out where the propeller should be and could be easily throttled in flight by putting finger pressure on the shaft. This technique turned out to be a most efficient active control system as its power absorption was most minimal when the craft was at its operational ceiling (i.e. highest frequency tone). A single AA battery served as the power system and was installed in the bomb bay area.



The plane was light and maneuverable. It had a long sustained flight time and a high operational ceiling. But the housing was fragile. So fragile, in fact, that the craft was judged as incapable of front line entry into hostile territory and so could only be used in studio work or in pass-and-review parades.

Housing was soon identified as a major consideration in the design of MGO. Good housing has to be light (for ergonomic reasons) yet strong and flexible (to withstand the occasional crash landing). **Godzilla** had all of these qualities but she was made out of several pieces which would tend to fall apart (especially the arms) during a long tour. The **Flying Glove** was strong and flexible but it was not light. The **TBF Avenger** was light but not strong. Another consideration is that the craft had to be easily positioned in a way that the motors would be close to the guitar's pickups. To understand why, see the sidebar entitled How MGO Works.

Housing was also the major problem with the old **Orbital Spaghetti**. Originally, the **Orbital Spaghetti** was an "in series" connection of about a dozen motors glued to the bottom of a plastic facsimile of a plate of spaghetti with a fork drawing some of the spaghetti up (as if to be eaten). The craft was not ergonomic, its housing was fragile, and its operational theater was short. For those reasons, it was retired. I didn't want to just "let it go into that good night", though, because its theatrics and aesthetics were quite superb. So I redesigned it. What I came up with was this: mount the plastic spaghetti on top of a coffee can whose power systems are on the outside of the can and whose engines are inside, cluster-mounted around the longitudinal axis of the can (closer to the spaghetti than the opening). The can itself is made of conductive material; thus the magnetic fields of the motors will not penetrate the walls of the can. They will instead bounce off and eventually be focused into going out the open end of the can. Thus the can serves as an Electro Magnetic Cavity Resonator (HALLIDAY78). EMCR technology is employed in many areas of telecommunications, from microwave transmitters to satellite disk antennae. A pure acoustic analog of this phenomenon is the megaphone. Although this redesign of the **Orbital Spaghetti** is still bulky, it allows for something easy to grab onto. It also employs a passive control system as, since the magnetic field is focused, the device is directional. Whether the can is pointed at the pickups or not will not affect the rate of power consumption.

I keep mentioning *control systems*; now is the time to talk about them. Control systems are the parts of the craft that control how it operates. There are two types; active and passive. Active control systems absorb power thus their use decreases the theater of operations for the craft. Passive systems do not consume additional power. For this reason they are more desirable. Potentiometers and motor shaft throttling are used to change the frequency of a motor. In terms of the circuit, both techniques are seen as a form of variable resistor and are, as such, categorized as active control systems. Motor shaft throttling is more responsive than potentiometers but, in the heat of battle, the pilot will tend to over-torque the motors which will burn them out. EMCR aiming and positioning of the motors with respect to the pickups vary the amplitude of the signal which effectively changes the volume. They are considered as passive for they don't affect a change in the circuitry. On/off switches are seen as passive because when the switch is on it is transparent to the circuit and when it is off the circuit is broken and there is no power consumption at all.

Another aspect of control systems is how *cybernetic* they are. That is to say how intuitive it is to use them. This design parameter overlaps with ergonomics. Motor shaft throttling is more cybernetic than potentiometers. It is theorized that EMCR aiming will be more cybernetic than motor positioning because the former involves wrist movement only whereas the latter involves movement of the entire arm and shoulder. I predict that, in the world of MGO, EMCR will be the future "whammy bar" of volume control.

While I was concentrating on control system parameters, Davey was concentrating on finding a new and better housing. That was when he found the housing for the **Aerial Shark**. The housing is essentially a facsimile of a dangerous shark made out of one of the new superplastics. It is very strong, yet flexible and light. Unfortunately, this new project led to the re-allocation of motors that were slated for the **Orbital Spaghetti**. Since then, the **Orbital Spaghetti** has been zero funded, but I am confident that I can get the funding pushed through eventually. The superior housing of the **Aerial Shark** puts it in the role of workhorse for Davey's vast armada of MGO. The motors are mounted under the wing fins.

Though this story must end, the fight continues. Our enemies are legion so we work hard, day and night, to build a more perfect MGO. Through experimentation with such design parameters as aesthetics, theatrics, power, fault tolerance, ergonomics, housing, and cybernetics, we have succeeded in reducing the MGO gap but we cannot rest on our laurels. To do so would spell disaster! Since mankind's evolutionary claim to fame is linked to his role as the tool wielder, then, if we are to grow, our tools must grow with us.

HOW MGO WORK

Theoretically, a MGO is any configuration of electromagnetic motor(s) that is used to interfere with the magnetic field of an electric guitar's pickup(s). Such interference creates a signal in the pickup that is amplified and, when skilfully manipulated, creates interesting and experimental music. A guitar pickup transduces the vibration pattern of a metal string through generation of an alternating current in a coil(s) of wire via a change in the magnetic field surrounding the wire (BAIRD90).

This is possible through a phenomenon called magnetic induction. Michael Faraday showed, in 1831, that when you move a magnet closer to or farther from a loop of conducting wire (thus changing the magnetic field as seen by the wire) a current of electricity is induced to flow within the wire (HALLIDAY78). It is easy to imagine what direction the current will take in the loop. Simply take your right hand and make the universal symbol for hitchhiking. If your thumb is pointing in the direction of the motion of the magnetic field relative to the coil, then the curl of your fingers shows which way the current will flow. This is how single-coil pickups (like those on Fender Telecasters and Stratocasters) work.

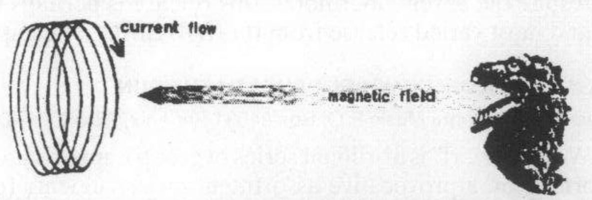


FIGURE 1 This is how magnetic induction helps MGO operation in single coil pickups. Note that **Godzilla**'s ectoplasmic vomit stream represents the direction of movement of the magnetic field as seen by the coil. Here **Godzilla** is relatively distant from the pickup.

The coil is wrapped around a single bar magnet or series of magnetized pole pieces. In normal operation the vibration of the strings changes the field, thus inducing the current which eventually becomes the signal that the amplifier boosts (DENYER82). In MGO operation, the additional magnetic field created by the rotating magnets and/or coils of an electric motor moves across the pickup's own magnetic field.

Dual coil, Humbucking pickups (like those on Gibson guitars) (DENYER82) are similar except for the addition of a second coil. The dual coil system is designed to eliminate unwanted signal from distant sources, and instead pick up only the signal from very near sources (normally the strings). It does this by having the two coils wound in opposite directions and connected as shown. The result is that while a given motion of a magnetic field relative to the coils will cause current in the same rotational direction in the coils, the two inducted currents will be in opposite directions in the single wire from which both coils are wound, and they'll cancel. This will be the case whenever the source of magnetic field movement is relatively distant, because the field movement relative to the two coils will be nearly parallel. But for nearby sources, the magnetic field movement relative to the two coils will not be parallel, as the angle of incidence will differ for each. The inducted currents will not be equal and opposite, and so won't cancel.

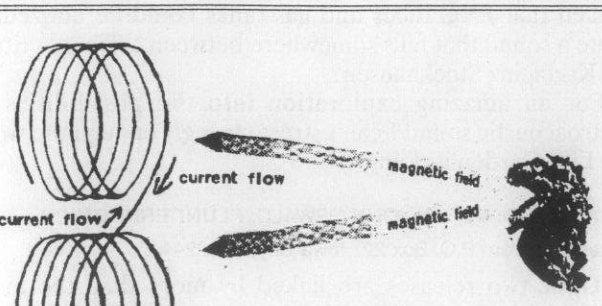


FIGURE 2 In dual coil MGO operation with **Godzilla** held far away from the coils, the phase angle (the angle between the two vomit streams) is small. Thus the inducted current flows from the two coils counteract each other, canceling each other out.

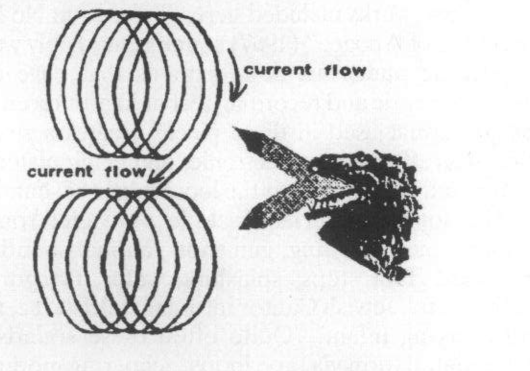


FIGURE 3 In dual coil MGO operation with Godzilla held close, the phase angle is large. Thus the inducted current flows from the two coils complement each other and the signal is enhanced.

Thus, the hum of distant magnetic fields (for which the phase angle of the interfering field between the two coils is small) is attenuated, but the hum of close fields (large phase angle) is increased! This is desirable in MGO playing for it gives the musician a large dynamic (volume range) that is controlled by the distance between the MGO and the guitar's pickups. Davey uses a Steinberger guitar which employs a system of two dual coil, humbucking, active EQ pickups made by EMG.

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RECORDINGS REVIEWS

By Mike Hovancsek

VLADAMIR USSACHEVSKY: **FILM MUSIC**

On CD from New World Records 701 Seventh Ave. New York, NY 10036.

Finally available on CD, these two works are great examples of Ussachevsky's synthesis of the French musique Concrete and the German pure electronic schools that developed in the 1950s. As the co-founder and director of the Columbia-Princeton Electronic Music Center, Ussachevsky (1911-1990) recorded a number of pieces (often times in collaboration with Otto Luening) that were milestones in the development of electronic music/tape music.

The two works included here, "Suite from No Exit" (1962) and "Line of Apogee" (1967) sound remarkably well recorded despite the numerous developments that have occurred in electronic music and recording technology in recent years. The collage format used in these pieces creates a stream-of-consciousness effect as the electronics and manipulated recordings surface and disappear into the loose fabric of sounds.

The source materials include pure electronics, distant children, men laughing, gun shots, animal sounds, crackling fire, wind, foot steps, splashing water, Gregorian chants, glockenspiel, Jewish Cantor intoning, telephone, flute, piano, and a crying infant. Quite often these sounds appear in manipulated form via tape loops, echo, ring modulation, tape speed variation, feedback, tape cutting, and numerous other techniques.

"Film Music" is an important document of the work that changed the way people produce/listen to music. Not many CDs can boast of being both entertaining and historically significant. This one can.

VOICE OF EYE: **MARINER SONIQUE**

On CD and cassette from Cyclotron Industries P.O. Box 66291 Houston, TX 77266-6291.

This recording is a series of improvised pieces utilizing non-standard instruments (e.g. squawk box, string-pipe, tape-machine-thing, spring-thing 2...). These instruments are often heavily manipulated with echo and other forms of electronic processing.

The result is a thick broth of drones/textures that serve as an adhesive to hold the varied timbres together where they would, otherwise, appear rather sparse and fragmented.

The thick walls of sound created by this group (portions of which were recorded live) are impressive in their richness and density. It is ironic, however, that the same quality that is impressive about this recording is also the quality that detracts from the overall listening experience. It is very difficult to listen to 90 minutes of thick drones in one sitting without craving a little concrete structure once in a while.

The instruments listed in the liner notes sound very interesting. Unfortunately, the artists don't take the time to explain them so that listeners can appreciate them. Instruments like the squawk box and the string-pipe deserve more attention than they get in the "Voice of Eye" liner notes. With any luck, this group will continue to produce more interesting music (preferably with less space echo) and listeners will be able to hear more of/about Jim Wilson and Bonnie McNairn's instruments.

VARIOUS ARTISTS: **JACKSONIAN MARCH**

On cassette from WiDEMOuth Tapes P.O. Box 382, Baltimore, MD 21203.

This compilation, assembled under the direction of John Berndt, is a series of pieces by tENTATIVELY, A cONVENIENCE and others who have worked with him. Surprisingly, most of the pieces on this tape are process pieces where in the past these people have worked in a live, primarily improvised format.

It is a nice change to hear these people doing a series of short pieces each with a different approach to music. Even the weaker pieces on this compilation are pardonable because they offer a variety and contrast that is usually lacking their releases.

Perhaps the strongest moment on this tape is a spoken word piece in which two people read different texts simultaneously (it's a lot more interesting than I make it sound as I try to describe it here). Other pieces include tape manipulation, electronics, and manipulated instruments. It is very difficult to determine who plays what because the liner notes are nonexistent. This is unfortunate since the main reason people buy compilations is to discover new people who are making music.

Despite the absent liner notes, this release is perhaps the best and most varied release from the WiDEMOuth camp.

LIFE GARDEN: **WORLDS WHIRL BENEATH THE SUN**

On cassette from Agni Music P.O. Box 84031 Phoenix, AZ 85071-4031

"Worlds Whirl" is a brilliant series of group improvisations performed on a provocative assortment of instruments (e.g. angklung, gamelan bells, gas tank, Japanese fiddle, water drums, cello, PVC pipes, and multi-effect units).

Most of the pieces evolve between lush drones and intense, tribal rhythmic passages with seamless accuracy. The dark mood of this tape evolves some powerful, ominous images as the grinding earthiness of the chosen instruments wafts about over the ever changing percussive patterns.

Thank God these people didn't try to play synthesizer on this tape. The complex sounds of the electroacoustic instruments in "Worlds Whirl Beneath the Sun" are *far* too interesting to be buried in sterile electronic sounds that can generally be expected from synthesizers.

The remarkable part of these pieces is the subtle acoustic element that reflects itself in every sound. Who would have guessed that PVC tubes and gas tanks could be utilized to create a sound that falls somewhere between a Tibetan ritual and Karlheinz Stockhausen?

For an amazing exploration into the possibilities of electroacoustic sound I can't stress strongly enough the work that Life Garden is doing.

NEGATIVLAND: **U2**, and JOHN OSWALD: **PLUNDERPHONICS**

On cassette from P.O. Box 227 Iowa City, IA 52244.

These two releases are linked by more than the mere similarities in the way that they are constructed. Both releases have been targeted for destruction by major record labels.

Negativland is a group that often mixes manipulated recordings of T.V. commercials, records, radio broadcasts, and the like into their compositions. Most of the manipulation techniques used in their work were originally developed by people like John Cage and Vladamir Ussachevski over four

decades ago but, unlike these earlier pioneers, the members of Negativland intentionally "steal" sounds from the various forms of media that surround us all. The results are a musical commentary on our society.

"U2" was originally a 7" record by Negativland that incorporates a few seconds of a song by U2 entitled "I Still Haven't Found What I'm Looking For," short snippets of Casey Kasum talking about U2, and other appropriated sound cuttings with accompaniment and a hilarious recitation of the "I Still Haven't Found...." lyric.

"Plunderphonics" was originally a CD of pieces by John Oswald constructed entirely from snippets of other people's music. The result, a modern musique concrete that is at once new and familiar was never intended for sale. Anticipating legal troubles, Oswald was content to give away copies of his CD.

Shortly after release of these two projects, threats of litigation surfaced from the commercial music industry. John Oswald and Negativland were ordered to destroy their master recordings, all copies, and all the covers printed.

This conflict arose because people are producing music that tampers with unresolved legal issues in music. The airwaves are full of music packed with samples of other people's music. Are Negativland and John Oswald doing something wrong by recording "U2" and "Plunderphonics"? Send a 90 minute cassette and postage to the above address for a free copy of both releases. Judge for yourself.

VARIOUS ARTISTS: **ECHO: THE IMAGES OF SOUND II**

On CD from Het Apollohuis, Tongelresestraat 81 5613 DB Eindhoven, The Netherlands.

This CD is the follow-up to "ECHO I", a series of essays focusing on the work of various sound artists. "ECHO II" is also focused on unusual forms of sound generation including works by many of the big names in this genre.

Most of the pieces on this CD are abrasive, textual works of a very minimalistic nature. Many of them were recorded at the Het Apollohuis festival of Sound in 1987 as a document to the event. The few pieces that were not recorded at the festival were included because the contributing artists performed pieces at the festival that were not recordable for one reason or another.

The most whimsical piece on this recording is Richard Lerman's Composition for three amplified bicycles which sounds like a monotone gamelan orchestra. His second piece on this recording, "A Footnote from Chernobyl" is a remarkable installation for four tuning forks (of different pitches) hung between two rocks. Small motors cause the tuning forks to vibrate and to touch the rocks.

Martin Riches' percussion machine is a machine that utilizes photo-sensitive cells to "read" a graphical score. The score moves through the machine on a pianola-like conveyor belt and activates the small mallets that beat out the information on woodblocks.

Terry Fox contributes a piece for a long-string installation here and Joe Jones displays his "Small Orchestra" (a collection of percussion instruments installed in a baby carriage all of which are set into motion by the vibrations of the movement of the carriage)

One of the denser pieces on this release is Takehisa Kosugi's installation for an AM radio transmitter, a fan, and an old radio. Sounds are produced as the transmitter (which is hung above the radio) is swung by the fan, thus, creating interference on the radio.

Walter Fahndrich's "Improvisation" is an incredible piece for viola that finds him creating several tones and overtones simultaneously; and Yoshi Wada's contribution (not recorded at Het Apollohuis) is a wonderful piece for bagpipe, siren, trash can, alarm bell and computer.

Jean Weinfeld's numerous amazing stringed instruments were included in the festival but the excerpt included on this recording (from a performance by Matthiew Sadowsky) is a disappointing sixty one seconds of ineffective noise that fail to explore the worthwhile elements of the instruments.

Christina Kubisch's piece (not recorded at Het Apollohuis) is a wind-like work for phased white noise. The Paul Panhuysen/Johan Goedhart installation for long strings (played by electrical wires swung from motors) is an abrasive work that provides some difficult listening.

The Horst Rickels' installation is a series of PVC tubes blown by a machine and modified by placing flutes, hands, and ping-pong balls over the ends.

Finally, Jim Pomeroy performs a multi-media work involving modified record players, a vacuum cleaner that operates a home-made panflute made of cardboard, and a huge assortment of visual elements.

Some of the pieces on this CD require the audience to see as well as to hear the music because the process that is utilized to generate the sound is often as important (sometimes more important) as the sound produced. This is a limitation that occurs with the release of recorded matter in this genre. Fortunately, the people at Het Apollohuis include a wealth of written information and photographs that help to make up for the audience's absence from the actual installations.

VARIOUS ARTISTS: **WHAT?**

On CD from Curious Music 13773 Sundown Rd. Dubuque, IA 52002-9685.

This compilation assembles the works of a number of important composers/musicians into a release that (for the most part) successfully straddles the line between continuity and variety.

Asmus Tietchens' "Beutelgesell" is a piece for a prepared and extensively treated steel guitar that sounds more electronic than guitar-like.

Michael Winnerholt's sound collage created entirely with sounds collected at the Olympic Summer Games in Seoul is extremely effective as are the two "Timbre Maps" that John Wiggins recorded using computer generated electronics.

Two percussion pieces, one by Charles K. Noyes and one by Fredrick Lonberg-Holm, display two very different methods for the percussive medium. Where the Charles K. Noyes piece is a wonderful piece for percussion and synclavier that showcases the interaction between man and electronics, the Fredrick Lonberg-Holm piece is a composed piece that could easily have been performed live.

"I'm Desperate/Positive Will" is a tape manipulation piece made from material stolen from television and records by the Tape- Beatles and "Joaquin Murphy" is an interesting piece by Chas Smith for a modified Pedal Steel guitar.

Overall, this CD is a great display of a wide range of musical ideas from many of the essential innovators working today.

Recordings featuring unusual musical instruments can be sent for review in **Experimental Musical Instruments** *directly to Mike Hovancsek, Pointless Music, 243 Commanche Pl., Kent, OH, 44240, or to EMI at Box 784, Nicasio, CA 94946.*

NOTICES

If any readers have any printed information (catalogs, manuals, etc.) on the Maestro Theremin, or remember or know when they were made, Please send information to Gino Robair Forlin at Rastascan Records, P.O. Box 3073, San Leandro, CA. 94578-3073.

Looking for people with Ensoniq EPS to participate in study of musical consonance/dissonance. Participants get a free disk. Thanks! Bill Sethares, 622 N. Henry St. Madison, WI 53703.

MICROTONE GUIDE. 34 page booklet of microtunings for synthesizers or new instruments. Ethnic, historic, just, and equal tunings. Good sourcebook for beginning microtonalists. $7.50 to C. Fortuna, 1305 Hartrick, Royal Oak, MI. 48067

Video Comp project looking for submissions for consideration preferably high quality. Live or studio. Experimental music/performance. For more info contact: Peter De Mattia, 8 Haddon Road Hewitt, N.J. 07421-2329. (201)853-4420

MUSIC FROM THE JAWS OF SOUND, improvisation on the electro-acoustic sound palette designed and built by Hal Rammel, is now available from Cloud Eight Audio. This 60 minute cassette may be ordered for $8.00 ppd. from Cloud Eight Audio, P.O. Box 1836, Evanston, IL. 60204-1836. Checks of money order payable to Hal Rammel.

We're assembling a compilation tape to be released on DINN International. This tape is limited edition / 400 copies. This tape will function as a promotional tool for contributers. All contributers will receive 3 copies of the tape. Thrashmetal, Hardcore, Industrial, Electronic, Ambient and other similar elements are available. These type of sound has small market in Tokyo, so we would like to develop it. Please send us your mastertape. Masters should be on Cr02 Cassette (Dolby B, C or NO) or R-DAT. Please also send biography, visual or information. Please don't send too long time sound. All contributions should be received before the 31st December 1992. DINN INTERNATIONAL. P.O. Box 86 GIFU CENTRAL 500-91 JAPAN

IDEA: INTERNATIONAL DIRECTORY OF ELECTRONIC ARTS 1992-1993 lists organizations, artists, people and periodicals in the field of art & technology, with over 2,800 addresses, four indexes. Bilingual, French & English. From Chaos Editions, 57, rue Falguière 75015, Paris, France.

ASIA PACIFIC FESTIVAL CONFERENCE takes place Wellington & Auckland, New Zealand, Nov 27 -Dec 6, 1992. A celebration of contemporary & traditional music & related arts of the Asia Pacific region. Information: Asia Pacific Festival & Conference, C/- Composer's Association of New Zealand, PO Box 4065, Wellington NZ, Fax (0064)-4-495 5157.

Sale! SCRATCH MY BACK: A PICTORIAL HISTORY OF THE MUSICAL SAW AND HOW TO PLAY IT, by Jim "Supersaw" Leonard. Prepaid $15 per book; U.S. dollars; includes mailing ($22.95 value). KALEIDOSCOPE PRESS, Janet E. Graebner, 28400 Pinto Drive, Conifer, Colorado 80433-5309.

IBM CLONE FREEWARE for JUST INTONATION. Freestanding program calculates just modulations/demodulations/intertones/complements, as well as string positions and ratio to cents. Menu driven, includes source code. Send formatted disk 51/4 or 3.5 inch, one dollar return postage (suggested) or trade material. NOVOSONICS, RFD 1 Box 312, Contoocook, NH 03329.

QUARTZ CRYSTAL "SINGING" BOWLS", frosted and clear in 12 sizes, in all musical notes available – magical – powerful healing tools for meditation and stress elimination, balancing energies, etc. Also available: handheld square drums, hoop and dance drums as well as water and ceramic kettle drums, various types of RAINSTICKS, melodious chimes, bells, cymbales. Largest distributor, lowest prices. The CRYSTAL STORE 1-800-833-2328.

EMI BACK ISSUES: Bound volume sets Vol I through Vol V: $17 per volume. Single issues Vol VI #1 through Vol VII #6: still $3.50 per issue. Single issues Vol VII #1 and later: $6.50 per issue. These prices include postage for U.S., Cananda & Mexico air, and overseas surface rate. For overseas air add 20%. Order from EMI, PO Box 784, Nicasio, CA 94946, or write for complete listing of back issues and their contents. Corresponding cassette tapes also available for each volume; see information below.

CASSETTE TAPES FROM EMI: $8 per cassette for subscribers; $10.50 for non-subscribers. Prices include postage for U.S., Canada, Mexico air, and overseas surface rate. For overseas air add $20%. Each tape contains music of instruments that appeared in the newsletter during the corresponding volume year, comprising a full measure of odd, provocative, funny and beautiful music. Our supplies of Volumes I and IV are nearing exhaustion and guess what? We ain't gonna press more of them when they're gone. Order from EMI, Box 784, Nicasio, CA 94946.

"Detuner" (no author credited), in **Sublimited** #0 Summer 1992 (c/o Friday Vlad Prod., "Lawton", Hadlow Down, Nr. Uckfield, E. Sussex, TN22 4HJ, England).

Ruminations on the process of creating music independent of inherited conventions relating to tunings, sound sources and the like.

"Music and Noise" (no author credited), also in **Sublimited** #0 (address above).

Reflections on the involuntarily-heard noise environment and its relation to sound awareness and musical sound.

"The Complete Home Build Monorad Mark V D.I.Y. Easy Synth + " (no author credited), also in **Sublimited** #0 (address above).

Schematic for a home-buildable electronic keyboard instrument.

"George Mallette: Dancer, Drum-Maker" by Rupert Kettle, in **Percussive Notes** Volume 30 #6, August 1992 (701 NW Ferris, Lawton, OK 73507).

Notes from an interview with a maker of drums in the traditions of North American Indians, including information on construction procedures.

Also in **Percussive Notes** Volume 30 #6 (address above): a short report on Fredrico Percussion Company's Spring Thing, "the offspring of a marriage between a berimbau and a reco-reco," with a spring mounted on a stick having the cup-shaped metal equivalent of gourds at each end, allowing for shifting resonance effects by rocking the open end of the gourd on the player's stomach.

"The Hot Chocolate Effect" by Frank S. Crawford, in **American Journal of Physics** 50 (5), May 1982.

A study of the pitch bending effects resulting from changes in wave travel speed due to changes in resilience and density of the medium – specifically, the rise in pitch in the longitudinal modes of a tall glass of aerated liquid as the air bubbles rise to the top.

"Lowest Modes of a Bottle" by Frank S. Crawford, in **American Journal of Physics** 56 (8), August, 1988.

Formulas for predicting modes of vibration for the air contained in long-necked bottles.

"Hot Water, Fresh Beer and Salt" by Frank S. Crawford, in **American Journal of Physics** 58 (11), November, 1990.

A further extension of the discussion of the "Hot Chocolate Effect" from the article mentioned above, applying similar principles in a more sophisticated manner to obtain clearer tones and a wider range.

"Sympathetic Strings" by Ephraim Segerman, in **FoMRHI Quarterly** #67, April 1992 (Fellowship of Makers & Researchers of Historical Instruments, c/o Faculty of Music, St. Aldate's, Oxford OX1 1DB, U.K.)

A review of physical behavior and approaches to tunings for sympathetic strings (i.e., extra strings designed to add reverberation to an instrument's sound, but not to be played directly).

"An Analysis of Irish Harp Scaling" by John Downing, in **FoMRHI Quarterly** #68, July 1992 (address above).

An analysis on surviving data on historical Irish harps in an effort to, if not replicate historical string scalings, at least come up with reasonably appropriate ones.

"John Cage & John Zorn on Record" by Douglas Kahn, in **Musicworks** 53 Summer 1992 (1087 Queen St. West, Toronto, Ontario, Canada M6J 1H3).

Not a discography for Cage and Zorn, but rather a discussion of their use of and attitude toward the dislocation of sound through recording, and toward recording as musical medium and musical source material.

"The Body as Organ" by Julia Loktev, in **Musicworks** 53 Summer 1992 (address above).

A celebration of body sounds as musical material.

"Logos-Duo in Lugo" by Moniek Darge, in **Logos-Blad** 14 #7 (Kongostraat 35, 9000 Gent, Belgium).

Included in this article (in dutch) are drawings for some simple musical instruments.

"A Book of Moves" by Godfried-Willem Raes, in **Logos-Blad** 14 #9 (Address above).

"A collection of 16 musical compositions for solo mover using the author's Holosound system." Godfried-Willem Raes talks about applications for his sonar-based system for translating body movement into sound patterns.

"Travels in French Lutherie" and "A Visit with Maurice DuPont" by Paul Hostetter, in **American Lutherie** #30, Summer 1992 (8222 South Park Ave., Tacoma, WA 98408).

A look at innovative French guitar designs. The first article focuses on earlier work (circa 1930s) by several makers, and the second on one contemporary maker.

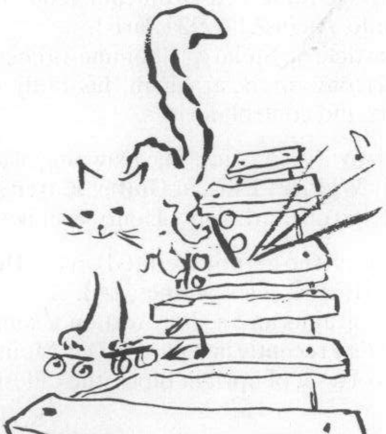
"Free Plate Tuning, Part 3: Guitars" by Alan Carruth, also in American Lutherie #30 (address above).

The third installment in this series on plate tuning, the practice of fine-tuning the wood in string instrument soundboards.

"Taking the Guitar Beyond Equal Temperament" by Don Musser, also in **American Lutherie** #30 (address above).

A report on Mark Rankin's interchangeable fretboard technology, and the author's impressions of the sound of a guitar refretted for just intonation.

Elderly Acoustic Instruments and Accessories Catalog #92A-1 (1100 N. Washington, PO Box 14210, Lansing, MI 48901) is the 1992 catalog for Elderly Instruments, containing pictures and information for a wide range of instruments both conventional and unusual.



The following is a listing of selected articles relating to musical instruments which have appeared recently in other publications. If you come across articles that are appropriate for inclusion here, please send a copy along with the name, address and date of the publication to EMI at Box 784, Nicasio, CA 94946. To the many who have sent articles for inclusion in this issue's listing, thanks.

"Acoustics of Drums" by Thomas D. Rossing, in **Physics Today** Vol. 45 #3, March 1992 (335 East 45 Street, New York, NY 10017).

A technical study of vibrational modes in several types of drums, including analysis of drum head modes, drum body modes, and their interaction.

"Sound from a Wall of Water: Some Notes about the Sounds of the Driftless Dreamtime" by Liz Was, in **Dreamtime Talkingmail** #2, Spring 1992 (Dreamtime Village, Rt 2 Box 242W, Viola, WI 54639).

Descriptions of the wide variety of instruments made at Dreamtime Village (a project of Xexoxial Endarchy) from recycled, found and indigenous materials.

Koukin Journal: A Biannual Journal for the Jew's Harps of the World (1-12-24, Midorigaoka, Ageo, Saitama 362, Japan) has been appearing since December, 1990. No. 3, December 1991 (the most recent to reach EMI at the time of this writing) includes reports on the 2nd International Congress on Koukin (Jew's Harp) Music, information on several traditional types of Koukin from the Pacific and East Asia, and description of an innovative design by Professor IWAKI Masao of Wako University. All in Japanese, with English abstracts.

"Pierre Bastien" interviewed by Albert Durand and Jérôme Noetinger in **Revue Corrigée** #13 (25, rue Docteur Bordier, 31800 Grenoble, France)

An interview with Pierre Bastien, maker of mechanically-played instruments using Meccano parts, with photographs.

"The Music Laboratory of the Model Secondary School for the Deaf" by Charlie Allan and Howard Schlieper, in **Open Ear**, Summer 1992 (6717 N.E. Marshall Rd., Bainbridge Island, WA 98110.

A report on music facilities at a school for the deaf, including vibrating floor, illuminated tempo indicators, and color organ.

"Le mariage du lézard et du cam"léon" by Denis Fortier, in **Le Monde**, August 1 1992 (Paris).

An article on Stelarc, "l'homme-orchestre électronique" " the electronic orchestra man, his body covered with wire, speakers and control devices.

"Tomorrow's Acoustics: The Dawning of a New Golden Age" by Andy Widders-Ellis, in **Guitar Player** April 1992.

A report on the designs of fourteen innovative guitar makers.

"Piping Up" (no author credited) in the **Des Moines Register**, August 31, 1992 (Des Moines, IA).

Photographs and a short text on a sound sculpture called *Pipes of Pan* recently installed in Des Moines. The installation consists of a set of upright pipes, the tallest of which is 21 feet.

"Strings Attached: Matt Heckert's Mechanical Sounds" by Sarah Cahil, in **East Bay Express** October 2, 1992 (Berkeley,CA).

An extended review of a sound installation by Matt Heckert at the University Art Museum at Berkeley, involving very large, moving, suspended metal parts controlled in real time by a computer operator.

"Steel Your Face: Post-C&W Metal Machine Music" by Josef Woodard, in **Option** (2345 Westwood Blvd. #2, Los Angeles, CA 90064).

An homage to the pedal steel guitar (an innovative and under-explored instrument, despite its pop-schlock associations) and some of its most adventurous players.

"Music on Traditional Maori Instruments" by Alan Wells, in **Listener & TV Times**, September 9, 1991 (New Zealand).

A review of a concert played on poiawhiowhio (whirled gourd), nguru (nose flute), putatara (conch trumpet) and other traditional Maori instruments, some reconstructed on the basis of oral accounts.

"A 30-year experiment in the acoustical and musical development of violin-family instruments" by Carleen M. Hutchins, in **Journal of the Acoustical Society of America**,92 (2) August, 1992.

A report on the development of the family of new violins developed by the author and other members of the Catgut Acoustical Society.

"Sounding the Future" by Don G. Campbell, in **The Quest**, Autumn 1992 (PO Box 270, Wheaton, IL 60189-0270).

Comments on sources for musical inspiration and musical sound in the future.

"Hawaiian Gourd Drums – Exciting!" by Anne Blanckenship, in **The Gourd** Volume 22 #3 (PO Box 274, Mt. Gilead, OH 43338-0274).

Notes on gourd drums such as the Ipu Heke (photograph included), and where to see them in Hawaii.

"Minnie Black's New Creations" by Minnie Black, also in **The Gourd** Volume 22 #3 (address above).

Minnie Black talks about her recent work with gourd instruments and other gourd craft, and provides a recipe for the filler/adhesive/molding material she uses to join gourds together.

"No Fancy Names, No Fancy Claims, Just Stuff That Works" by Jeffrey Vovakes, **Techni-Com" Volume 16 #3, May-June 1992 (PO Box 51, Normal, IL 61761).**

Recipes for mixing brass instrument valve oil, key oil, and tuning slide grease from commonly-available inexpensive materials.

"The Cloud Eight Orchestra: A Conversation with Musician and Instrument Inventor Hal Rammel" by Michael Gehrke, with photos by Richard Beauchamp, in **ArtMuscle** Vol. 7 #1, Oct/Nov 1992 (901 W. National Ave., PO Box 93219, Milwaukee, WI 53203).

An interview with Hal Rammel, including photographs of his instruments the Bibliolin, Hydro-Aerölin, Five-fold Horn, Triolin and Sound Palette.

(Continued on page 39)